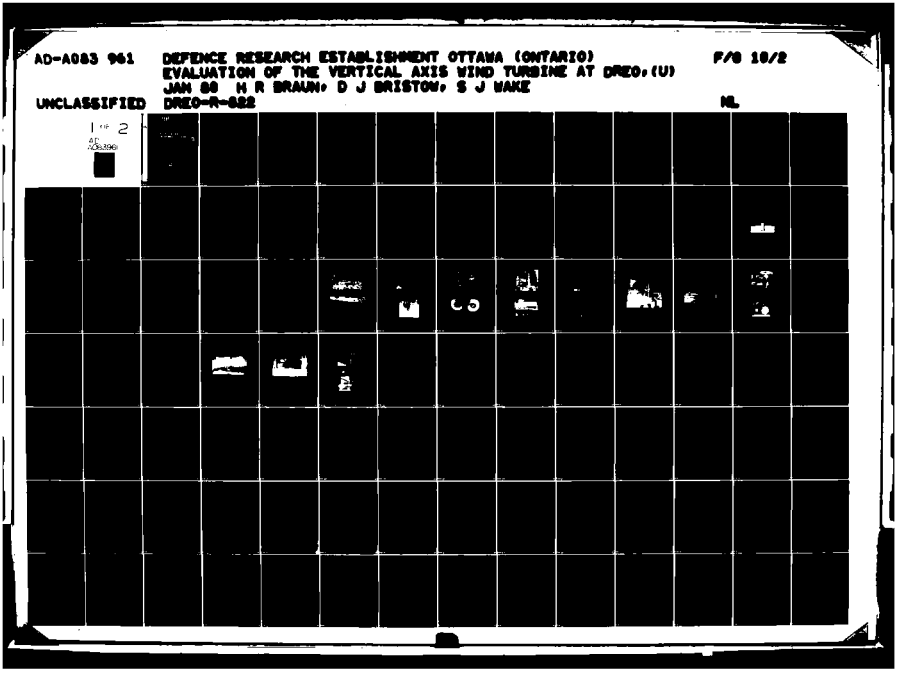
AD-A083 961 DEFENCE RESEARCH ESTABLISHMENT OTTAWA (ONTARIO) F/G 10/2
EVALUATION OF THE VERTICAL AXIS WIND TURBINE AT DREO.(U)
JAN 80 H R BRAUN, D J BRISTOW, S J WAKE
UNCLASSIFIED DREO-R-822 NL



RESEARCH AND DEVELOPMENT BRANCH
DEPARTMENT OF NATIONAL DEFENCE
CANADA

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

DREO REPORT NO. 822
DREO-R-822

EVALUATION OF THE VERTICAL AXIS WIND TURBINE AT DREO

by

H.R. Braun, D.J. Bristow and E.J. Wake

141

JANUARY 1980
OTTAWA

401576

RESEARCH AND DEVELOPMENT BRANCH

(3)

DEPARTMENT OF NATIONAL DEFENCE
CANADA

DEFENCE RESEARCH ESTABLISHMENT OTTAWA

REPORT NO. 822

EVALUATION OF THE VERTICAL AXIS WIND TURBINE AT DREO

by

H.R. Braun, D.J. Bristow and S.J. Wake

Energy Systems Section
Energy Conversion Division

JANUARY 1980
OTTAWA

ABSTRACT

A Vertical Axis Wind Turbine-Battery Storage System was installed at the Defence Research Establishment Ottawa (DREO) in December 1975 and was operated for three years. The system was instrumented to control and monitor its operation and performance.

This report deals with an evaluation study of a Vertical Axis Wind Turbine-Battery Storage System for a low-power unattended power source. The System's wind turbine, energy-generating and battery-storage system, mechanical drive system, installation, control-circuitry and data-acquisition system are described. Also, a performance-history outlining the problem areas encountered and a data-summary of two years of performance-data acquired during this study are presented.

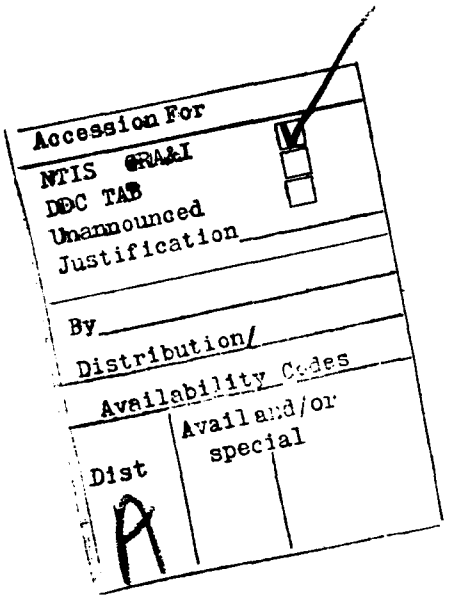
The objective of this study was to assess the System's ability to provide sixty watts of continuous power. The frequency of mechanical failures, especially in the turbine electrical drive system, made this particular system unsuitable as an unattended power source. It was also concluded that the average annual wind speed in the test location was of insufficient magnitude to provide the specified power output.

RÉSUMÉ

En 1975, une éolienne à axe vertical avec circuit de batterie d'accumulateurs était installée au Centre de Recherche pour la Défense-Ottawa et mise en service pour une période de trois ans. Elle était équipée de commandes et de dispositifs de contrôle automatiques.

Le présent rapport est une étude appréciative de l'éolienne à axe vertical avec circuit de batterie d'accumulateurs utilisée comme installation énergétique autonome de faible puissance. Il contient, en outre, une description du groupe turbine, du groupe électrogène, du groupe accumulateurs, du groupe entraînement mécanique, de l'installation, des circuits de commande et du système de collecte des données. Un dossier sur le rendement de l'éolienne y décrit les problèmes qui se sont présentés et donne un résumé des données réunies durant les deux années qu'a duré l'étude.

L'objectif visé était d'étudier la capacité de l'éolienne à produire une puissance permanente de soixante watts c.c. L'éolienne s'est révélée inefficace comme installation énergétique autonome à cause de la fréquence des défaillances mécaniques, particulièrement en ce qui concerne le groupe d'entraînement électrique de la turbine. En conclusion, il a été établi que la vitesse annuelle moyenne du vent à l'emplacement choisi pour l'essai était insuffisante pour fournir la quantité d'énergie projetée.



INTRODUCTION

This report deals with an evaluation and feasibility study conducted at DREO as part of a task (DCEM 29) "Low Power Wind Turbine-Battery System for the Arctic" performed for the Director Communications Engineering and Maintenance. The computer simulation portion of this task is reported in a separate DREO report (1).

The overall objective of the study was to investigate the ability of a Vertical Axis Wind Turbine (VAWT) - Battery Storage System (BSS) to provide continuous power. This required the integration and installation of a VAWT-BSS at the CRC/DREO (Shirley Bay) site. The VAWT-BSS was instrumented to measure and record the systems performance parameters. Some system modifications were made during the course of the study to improve the performance reliability of the VAWT-BSS.

A 15' diameter VAWT developed by the National Research Council (NRC) and manufactured by Dominion Aluminum Fabricating (DAF) is described along with the electrical energy generating system and the BSS. The aerodynamics of the VAWT system are not discussed since comprehensive references (2,3,4) are available. The evolution of the VAWT drive system and operating sites is discussed and a performance history of the VAWT-BSS is presented. The VAWT control circuitry and the data acquisition system developed to permit unattended operation and to monitor performance are described. Some resultant recommendations for improved performance and reliability are made.

15' NRC/DAF VAWT

The VAWT installed at the CRC/DREO site is a three-bladed device (see Figure 1). Each blade (airfoil) was fabricated from aluminum which was extruded into an airfoil (21' 3¾" long and 6" wide) symmetrical about its cord (see Figure 2). The blades are shaped to a near parabolic arc and are attached to the rotor such that the ends are 15' apart (see Figure 2). The rotor is the axis of rotation, when the attached blades are rotated and the blades circumscribe a volume with a maximum radius of 90".

A pair of overspeed spoilers are mounted midway along the length of each blade. Each spoiler (4¼" x 5" - 1/16" Aluminum) is attached to the trailing edge of the blade by a pivot pin so that the leading edge of the spoiler is flush with the inner surface of the blades (see Figure 12b). The pivot pin of the spoiler and the torsion spring holding the spoiler to the blade surface were designed to enable overspeed deployment at a rotor speed of ∿ 250 RPM.

The rotor of the VAWT is supported at the top by three steel guy cables and on the bottom by a 10' aluminum support tower. The upper end of the rotor is inserted into a bearing housing to which the steel guy cables are attached and the lower end of the rotor is inserted into a self-aligning bearing at the top of the support tower. The support tower is anchored to a concrete pad. The lower end of the upper support guys are anchored to ground at 120° intervals and sufficiently far away from the center of the support tower to ensure they do not interfere with the rotation of the rotor/blades (see Figure 2).

The electrical drive system is coupled to the section of the rotor protruding through the self-aligning bearing. Figure 3 shows the mechanical design of the original DAF electrical drive system. This drive system consisted of an 8:1 step up ratio from the rotor to the alternator and an 2.4:1 step up ratio from the alternator to the motor generator (M/G). The rotor to alternator drive consisted of a 3/8 pitch duplex chain-sprocket drive and the alternator to motor generator drive consisted of a 3/8 pitch single chain-sprocket drive. This system was eventually replaced with a drive system designed and fabricated by DREO which incorporated timing belts and pulleys. Reasons for this redesign will be discussed later on in this report.

Figure 4 is the block diagram of the DAF control system. With this system, the VAWT can either be driven by wind power or motored under battery power. A voltage sensing circuit monitors the output of the M/G, which when the turbine is being wind driven, is dependent on the RPM of the rotor. It therefore, can conveniently serve as a reliable indicator for switching in the alternator field.

The DAF control system was modified to enable the VAWT to be started up only when the wind speed was of sufficient velocity and frequency to support self-sustained operation. Figure 4 shows the component additions required to enable a controlled start up. A more detailed description of the start-up circuitry and reasons for changing to an anemometer controlled start up circuit are described later in this report.

THE VAWT ENERGY GENERATING AND STORAGE SYSTEM

Figure 5 is a block diagram of the VAWT electrical system. The M/G (Applied Motors Inc. #8A-3640-827 - $\frac{3}{4}$ HP, 1200 RPM, 24 VDC) is the motoring or start-up device for this VAWT. It is also the control element and the initial power generating stage because the alternator is a high speed device. When VAWT is switched on the M/G motors the rotor to approximately 60 RPM; during this period the M/G is consuming power. As the turbine starts to absorb power from the wind, at a transition point of $\sim$ 80 RPM of the rotor and $\sim$ 1500 RPM at the M/G, the M/G starts to produce power. When the rotor speed has increased to 155 RPM ($\sim$ 3070 RPM at M/G - see Figure 6), the M/G voltage trips a voltage sensor in VAWT control panel switching the system to the alternator (see Figure 4).

The alternator (Motorola #5A-70-24, 240 VDC, 70A) is the high current generating device and is field regulated. The alternator field is switched in by the control circuit at approximately 1350 RPM ($\sim$ 168 RPM at rotor). Figure 7 illustrates the relationship between the rotor RPM and output power. The alternator's output power is regulated by the field regulator and is dependent on the state-of-charge of the energy storage system.

The energy storage system (Figure 8) is comprised of 28 lead acid batteries (BB-248/U, 100 Ah, 24 VDC) connected in series-parallel to give 1400 Ah at 24 VDC. These batteries were stored in two wooden boxes insulated by 3$\frac{1}{2}$" of styrofoam. The batteries were electrically interconnected by #2 welding cable. The power leads between the VAWT support tower, control panel and the batteries consisted of approximately 140' of #2 welding cable and were calculated to have a 20W power loss at 1 kW.

The batteries are connected to the VAWT system control panel through a double pole, double throw knife switch (see Figure 5). This switch was incorporated to enable the batteries to be connected to the VAWT system or an external charger. The charging circuit was used in the event that the batteries became fully discharged during periods where no wind power was available. A current shunt to monitor the VAWT generator output current was placed between negative and earth ground. A current shunt to monitor load current was placed between earth ground and system load ($\sim$ 60W). These current monitors were fed to the data acquisition system.

THE EVOLUTION OF THE VAWT DRIVE SYSTEM AND OPERATING SITES

The first installation was completed in December 1975. The VAWT was mounted on top of a 40' timber tower, which elevated it above the trees surrounding the site. Figure 9a and 9b illustrate the installation. The NRC/DAF VAWT was installed as delivered from DAF, Toronto. The only modification made was to the start-up control circuitry.

Mechanical problems in the alternator-M/G drive linkage occurred within the first week of operation. Figure 10a and 10b illustrate the type of sprocket wear encountered. The primary cause of this wear was the inability of the drive system to hold lubricant, especially on the high speed alternator-M/G linkage (at a rotor speed of 155 RPM, the M/G sprocket chain is travelling at a speed of 31'/sec). Both Molilub® grease and G.E. G300® Silicon grease were tried; the G300® was the better of the two and worked reasonably well on the rotor-alternator linkage. Because the chain drives operated on a horizontal plane and ran at high speed, modifications to incorporate continuous lubrication were impractical. A modification of the alternator-M/G linkage was initiated to replace the chain drive with a timing belt drive. The modified drive system was installed in April 1976. Figures 11a and 11b illustrate this system; it will be noted that the rotor-alternator linkage was not changed.

In May 1976 spoiler malfunctions resulting from the fatiguing of torsion springs (see Figure 12) caused excessive vibration in the VAWT. The vibration loosened the guy lines which stabilize the VAWT support tower. This in turn caused a misalignment of the rotor-alternator drive linkage, which in turn caused excessive drive sprocket wear and necessitated sprocket replacement. The system vibration also weakened the timber tower. It became apparent that the tower did not have the stability required for this type of operation. A new operating site was found and work on relocation was initiated in May 1976. The installation in Figure 9a was dismantled in July 1976.

The new VAWT site required considerable preparation. The site required an instrument building (16' Atco trailer), electrical power, a concrete pad for the VAWT support tower, and guy wire anchors. Figure 13 is an inside view of the instrument trailer. A new data logger was purchased and the control system, the data acquisition signal processors and interfaces were redesigned. The new VAWT installation (Figure 14) was completed in November 1976 and the VAWT system was operational in December 1976.

In May 1977 a new DAF electrical generating system was received. This system basically consisted of a gear box and 4 kW Winco AC generator.

Bench tests were conducted on the system using a compressed air driven motor to simulate the rotation of the VAWT. It was found that at optimum conditions, only 20% conversion efficiency could be achieved. At rotor speeds of 120 to 200 RPM, the Winco generator output voltage ranged from 31 VRMS at 25 Hz to 96 VRMS at 50 Hz. The introduction of a gear box to step-up rotor RPM should have been a solution to drive system problems; however, the choice of gear system was inappropriate. The gear box chosen was a worm gear reduction type operated in reverse which did little to reduce the turbine starting torque. It was concluded that these performance parameters offered no advantage over the alternator-M/G system and this new system was not installed. Instead, since the alternator-M/G linkage using a timing belt had performed well, a redesign of the total electrical drive system was initiated in August 1977. The redesigned drive system shown in Figure 15a,b was installed in December 1977 and the system was operational in January 1978.

The new drive system consisted of two timing belt and pulley stages with a step-up ratio of 9:1 between the VAWT rotor and the alternator and one timing belt and pulley stage with a step-up ratio 2.18:1 between the alternator and the M/G. The resultant step-up ratio between the rotor and the M/G was 19.62:1.

The VAWT with the redesigned drive system was operated until December 1978. A few minor problems with the drive system were encountered, but nothing of a serious nature. A more detailed outline of VAWT problems encountered during 1976 through 1978 is found in the Performance History section of this report.

THE VAWT CONTROL CIRCUITRY

Figure 16 is a schematic of the modified DAF control circuitry. The modifications were basically the introduction of the relay K2 and the blocking diode D7.

The Q2 circuit is a voltage sensing circuit that activates relay K1 when the M/G generated output voltage reaches 44 volts ($\sim$ 155 RPM on rotor). The activation of K1 closes K1-1 and opens K1-2 contacts, energizing alternator field and limiting the M/G output power by introducing a 50Ω resistor R5 into the circuit. The lamps DS-1 to 4 (GE 250P25-32V) are used as ballast resistors to protect the M/G from excessively high output and start-up currents. The diode D2 enables the battery to be charged from the M/G when the M/G output voltage is high enough and the diode D1 and D3 enable the battery to supply power for motoring the M/G on start-up.

The Q1 and SCR1 circuit is an overvoltage protection circuit to protect the system in the event that the battery should become disconnected. If an overvoltage condition occurs, SCR1 is triggered and lamps DS-3 and 4

are switched in, introducing a load of approximately 350 watts at 24 VDC. A malfunction indicator DS-5 is switched on by Q1. This protection circuit was disabled after the circuit had tripped on two occasions for no apparent reason causing excessive discharging of the storage batteries.

In the original control the relay K1 was the M/G start-up control. The circuit was modified to enable external start-up control by placing a blocking diode D7 in series with the M/G and by introducing a relay K2 to short circuit D7 on start-up. The relay K2 is controlled by a wind speed sampling circuit which enables VAWT motoring only when sufficient wind velocity is present.

Figure 17 is a block diagram of the anemometer start-up control circuit. The wind transmitter (Belfort Inst. Co., Model 1250B) is a linear wind speed to dc voltage generator. The output is filtered and connected to a 50 μA meter relay movement (API Model 602L) scaled to 50 mph full scale. The meter relay has adjustable upper and lower limit sensors. The lower limit is used to set wind speed threshold (10 mph was selected) necessary for start-up. The limit sensor signal is fed to a comparator which gives a logical '1' for wind speeds above and a logical '0' for wind speeds below the selected wind speed threshold. This threshold logic level is fed to a sample circuit.

The wind speed sampling circuit is comprised of 1 PPM clock, a number of samples to start selector, a number of minutes on start selector and timer, a sample counter and a start-up control circuit. The samples to start selector sets the number of consecutive samples (logic '1') required to activate start-up circuit and the start-up time selector sets the number of minutes the start-up circuit is activated. In our case, 2 consecutive samples were required to activate the start-up circuit for 2 minutes. If the wind speed threshold is exceeded (logic '1') during 2 consecutive clock pulses (width of clock pulse $\sim$ 500 μsec) the sample counter activates the start-up control circuit and starts start-up timer (2 minutes). Should the wind speed threshold comparator change state during a sample period, the start-up is aborted, the sample counter is reset and the sampling sequence begins anew. The start-up control circuit is a relay driver which activates start-up relay K2 (see Figure 16).

A start-up inhibit circuit was incorporated in the start-up control circuitry. The inhibit signal is activated when the alternator field is energized (see K1 in Figure 16). This signal prevents wind speed threshold sampling. The primary reason for this circuit is to minimize start-up circuit operation while VAWT is running.

THE DATA ACQUISITION SYSTEM

The data acquisition system used to monitor the performance of the VAWT system is shown in block diagram Figure 18. The data system monitored and recorded the following parameters every hour:

(1) day of year and time
(2) average hourly windspeed (mph)
(3) energy produced (Ah)
(4) energy consumed (Ah)
(5) battery voltage
(6) temperatures: ambient; battery box 1; battery box 2.

The data logger used in this system was a Fluke Model 2240A equipped with a binary coded decimal (BCD) data input interface and magnetic tape recorder output interface.

The day of year and time were a data logger generated parameter. However, average, hourly wind speed, energy produced and energy consumed were generated in digital form by in-house circuitry (Figure 18) and connected to the data system via the BCD input interface. The data circuitry was reset after hourly data was printed.

Wind speed was monitored by an integrating anemometer (Science Associates, Inc. - Model 403). The anemometer initiated a contact closure for every mile of wind which passed. This contact closure was used to generate a clean data pulse. This pulse was fed to binary counters and a decade counter. The output of the binary counters was used to increment a digital to analog converter (DAC) whose voltage output represented the average hourly windspeed. The output of the decade counters were stored in output registers which were connected to the BCD input interface of the data logger.

The energy produced (Ah) was monitored by a current integrator connected across the generator shunt (see Figure 5). The current integrator consists of a digital voltmeter (DVM), DAC, voltage to frequency oscillator (VFO) and decade counters. The DVM monitored the generator shunt voltage, its BCD output was connected to a DAC and its output was fed to a VFO. The frequency representation of the generator current was gated to a prescaler if the generator shunt voltage was positive. The prescaler allowed one data pulse for every 0.1 Ah. The prescaler output was fed to decade counters and stored in data output registers. These output registers were connected to BCD input interface of the data logger.

The energy consumed (Ah) was monitored by a current integrator connected across the load shunt (see Figure 5). The operation of this integrator is similar to the one described in the previous paragraph. However, the prescaler in this case allows one data pulse for every .01 Ah.

The loading of output registers and the BCD input interface of the data logger is controlled in the following manner. The outputs of the anemometer signal processor or the prescaler are fed to a data up-date stroke circuit which will generate an up-date pulse if any of the three sources give a data pulse. The up-date pulse generates a data shift stroke which loads the output registers with data contained in decade counters. The shift stroke in turn generates a bar load pulse which shifts data in the output registers into BCD input interface of the data logger. This sequence continues until the data logger outputs hourly data. The $\overline{\text{BUSY}}$ signal from the BCD input interface is then used to generate a reset pulse to reset the BCD data counters and to restart the data sequence for the next hour of data.

The analog data to be recorded was connected to the scanner of the data logger. The data logger is micro-processor controlled, each channel may be independently programmed for voltage or temperature. Iron-constantan (Type J) thermocouples were used. A typical hourly data record is shown in Figure 19.

VAWT PERFORMANCE HISTORY

A chronological diary of major events and problems encountered during the evaluation of the 15' DAF/NRC VAWT is outlined in Table 1.

The performance data for 1976 prior to the relocation of the VAWT was incomplete due to the major mechanical problems encountered with the drive system. This data is not included in this report. The yearly and monthly summaries of the VAWT performance for the years 1977 and 1978 are found in Appendices A and B of this report.

SUMMARY

The main design goal of the DAF/NRC VAWT was directed toward a low cost alternative energy source to supplement 'third world' energy needs. The objectives of the evaluation of the 15-foot VAWT at DREO were to assess: the use of a VAWT system for specialized DND energy requirements; the mechanical integrity and reliability of the system; and the parameters required for utilizing wind energy. Observations made during this evaluation program and recommendations for the improvement of this system are discussed in the following paragraphs.

The VAWT rotor assembly, with the exception of the spoilers, operated without mechanical or structural failure for the duration of the program. However, when the VAWT was disassembled, the rotor-blade mounting assemblies (upper and lower) had experienced or showed signs of metal fatigue. The termination of this evaluation study undoubtedly avoided a major structural failure in the rotor-blade assembly.

The spoilers represented a major mechanical weakness in the system. The spoiler torsion springs were subject to fatigue and required frequent replacement (every 2-3 months when the VAWT was operational - see Figure 12a

and b). The spoilers were also subject to physical deformation in severe hail storms (see Figure 20). A redesign of the spoiler system should be undertaken or an alternate method of overspeed protection should be found to improve VAWT reliability.

The original electrical drive system (chain and sprocket drive) proved to be totally unreliable. This system was subject to excessive mechanical wear due to: the system's inability to maintain lubrication; the stretching and thermal expansion and contraction to the drive chains; vibrational misalignment; airborne dirt particles. The mechanical problems presented by this system would outstrip any cost advantage the system may have offered over systems such as step-up transmissions.

The DREO designed drive system (timing belt and pulley drive) proved to be reliable. A mechanical problem was encountered with the adapters which connect the pulleys to the electrical generating devices. This problem could be eliminated by more rigid design. The timing belts were subjected to some abrasion due to friction and airborne dirt; however, abrasion due to misalignment would be much more serious. Misalignment problems were eliminated by vibrationally isolating the drive system from the rotor with Paraflex® coupling. The timing belt and pulley drive system can be designed to offer a reliable and low cost drive system.

The VAWT electrical generating system (alternator and M/G) operated with reasonable reliability over the evaluation period of three years. The brushes of the M/G had to be replaced after 30 months and the alternator required a new bearing after 34 months. These were the only mechanical failures in these devices. On three separate occasions the alternator and its field regulator experienced electronic component failures due to electrical storms. The use of high speed electrical conversion devices in the VAWT system offer a cost and an availability advantage over low speed conversion devices.

Alternative systems which could increase the reliability of the VAWT system would involve the use of a step-up transmission in the drive system or the use of a direct coupled low speed alternator. A transmission must be of a type specifically designed for step-up applications and be able to contain its own lubricant. A possible candidate for this application could be a planetary gear system. A low speed alternator eliminates the need for RPM step-up and is presently being produced by a Canadian manufacturer (5). The use of either of these alternatives would significantly increase the overall cost of the VAWT system.

The VAWT system may be started in three ways: it may be continuously motored until sufficient wind power is available; it may be motored only when sufficient wind power is available or it may be self started by a Savonius rotor, which is an integral part of the VAWT rotor. A continuously motored VAWT represents a considerable parasitic load to the systems BSS and this loss must be taken into account when calculating the BSS requirements. The parasitic load on the system can be significantly reduced by incorporating a wind speed sensor which only allows motoring when wind speed is sufficient to sustain the VAWT operation. The self starting VAWT eliminates both the requirement for a wind speed sensor and any parasitic drain on the system. The self starting VAWT does not lend itself well to a system in which high speed energy conversion devices are used because of the introduction of high starting

torque (torque available is the rotor torque times the reciprocal of the step-up ratio).

The lead acid storage system was made up of 100 Ah automotive type batteries. These batteries were purchased in November 1973 and used in an earlier VAWT program using one of NRC's prototype VAWTs. They were incorporated into the present program in December 1975. It was not until December 1978, near the completion of this evaluation program, that these batteries showed definite signs of performance degradation. Considering their age these batteries performed reasonably well. A possible alternative to using automotive type lead acid batteries may be employment of the lead calcium motive power batteries presently being marketed and developed (6).

The selection of a site for a VAWT is a major consideration in determining the viability of utilizing wind energy in specific geographic regions. Geographic regions where high average wind speeds prevail such as coastal regions of the Maritimes, the perimeter of the Hudson's Bay, regions of southern Saskatchewan and regions of coastal British Columbia are the most promising prospects for utilizing wind energy on a large scale. Other regions in Canada, however, are capable of supporting the utilization of wind energy (average annual wind speeds of 10 mph and preferably greater). A proposed site should have at least one year of wind speed data and preferably more to support its choice. The average wind speed of a specific site in a particular region does not necessarily support the choice of another site in that region (e.g. Ottawa region - Uplands has an average annual wind speed of ≈ 10 mph whereas the DREO site 20 miles away has an average annual wind speed of ≈ 7 mph [see Appendix A and B]). Attempting to utilize wind power in a region where the average annual wind speed is not great enough is an exercise in futility.

Wind energy systems are generally mounted on towers or natural topographical prominences which make these systems excellent targets for lightning strikes during electrical storms. Any system should be earth grounded and should have lightning protection designed into its electrical system.

CONCLUDING REMARKS

Some observations relevant to the evaluation of the VAWT-BSS are:

(1) The VAWT system evaluated at DREO does not have the reliability required of a remote unattended power source for the Arctic. The VAWT system with a directly driven low speed alternator (5) may have the reliability required for this application.

2. The average annual wind speed at the DREO site (Ottawa region) was insufficient to support a 60W load (2 times the 30W power requirement) using the 15' diameter VAWT. A computer simulation program (1) confirmed that the VAWT could not have met the 30W power requirement at the DREO site.

ACKNOWLEDGEMENTS

The authors would like to express their appreciation to the following for their contribution in this study: the CRC/Plant Engineering Office and rigging crew; the DREO/PSD Engineering Office and Machine Shop.

REFERENCES

1. S.J. Wake, H.R. Braun and Capt. D.J. Bristow, "Computer Simulation of a Wind Turbine/Battery Storage System", DREO Technical Note in preparation, Defence Research Establishment Ottawa, Ottawa, Ontario K1A 0Z4, 1979.

2.

2. R.J. Templin, "Aerodynamic Performance Theory for the NRC Vertical Axis Wind Turbine", NRC/NAE, LTA-LA-160, June 1974.

3. P. South and R.S. Rangi, "A Wind Tunnel Investigation of a 14 Foot Vertical Axis Windmill", NRC/NAE, LTA-LA-105.

4. P. South and R.S. Rangi, "Preliminary Test of a High Speed Vertical Axis Windmill Model", NRC/NAE, LTR-LA-74.

5. LICUS®, A wind power system developed and manufactured by Bristol Aerospace Ltd., Winnipeg, Manitoba.

6. C&D Battery Division of Electra Corp., Perth, Ontario, commercial literature.

TABLE I

Performance History

Date	System		Remarks
	Running	Stopped	
1/12/75	X		The VAWT installation was completed (see Figure 9a and b).
3/12/75	X		Water was added to storage battery cells.
8/12/75		X	The M/G drive sprocket was badly worn (see Figure 10a)
10/12/75	X		The M/G sprocket was replaced.
12/12/75		X	The M/G sprocket was badly worn. This problem was attributed to improper installation.
16/12/75	X		The M/G sprocket was replaced.
22/12/75	X		It was found that Molilub® lubricant for drive chains was inadequate and G300® silicone lubricant was tried.
2/1/76		X	The battery capacity had become too low for cold weather conditions and the battery was put on charge.
7/1/76	X		The battery was taken off charge. The electrical drive system was retensioned. The drive sprockets showed signs of wear.
9/1/76	X		The Winnipeg installation (Dept. of the Environment) was experiencing similar drive sprocket problems.
16/1/76	X		A redesign of the alternator-M/G drive system was initiated.
26/1/76	X		The first icing conditions were encountered. The VAWT was operable, however, the start-up anemometer was inoperative due to ice build up.
27/1/76	X		The alternator-M/G sprockets were badly worn and replaced (see Figure 10a and b). A strange squeaking noise from VAWT upper bearing was noticed.
2/2/76		X	The upper bearing of VAWT was seized.

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
25/2/76		X	The alternator-M/G drive system redesign was started by the DREO engineering office. It was decided that a timing belt/pulley system be used in the redesign.
3/3/76		X	The redesign of the alternator-M/G drive system was completed. Fabrication and installation required.
8/3/76		X	The VAWT rotor assembly was removed from the support tower to facilitate the replacement of the upper bearing.
10/3/76		X	The upper bearing was replaced. The cause of this malfunction was improper installation when the VAWT was initially assembled.
5/4/76		X	The disc brake was overhauled.
6/4/76		X	The VAWT rotor was reinstalled.
7/4/76		X	The redesigned alternator-M/G drive system was installed (see Figure 11a and b).
12/4/76	X		The system was restarted.
6/5/76		X	A spoiler malfunction caused excessive VAWT vibration and start-up problems (see Figure 12).
17/5/76	X		The spoiler malfunction was caused by torsion spring fatigue. Spare torsion springs were not immediately available, so spoiler was removed.
21/5/76		X	A spoiler malfunction occurred and this malfunction caused excessive system vibration which resulted in support tower guys shaking loose. The drive assembly became very loose. This problem was attributed to the removal of the malfunctioning spoiler on 17/5/76 and the resultant stress on the remaining spoilers (one pair of which had torsion spring failure).

UNCLASSIFIED

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
28/5/76		X	The battery capacity was low and the battery was put on charge.
2/6/76		X	The electrical generating components of the VAWT system were removed.
3/6/76		X	The mounting bolts on the M/G bracket were replaced.
28/6/76		X	The VAWT rotor assembly was removed from the tower in preparation for moving VAWT to the new site.
7/7/76		X	The spoilers were modified to include brass bushings.
12/7/76		X	The remainder of the VAWT installation was dismantled for removal to the new site.
17/8/76		X	The battery was discharged.
30/8/76		X	The battery was recharged.
9/9/76		X	Water was added to the storage battery cells.
29/9/76		X	The VAWT support tower was installed at the new site.
1/11/76		X	The preparation of the new VAWT site was completed.
18/11/76		X	New spoiler torsion springs were installed on the VAWT blades.
30/11/76		X	The VAWT was reassembled at new site (see Figure 14 and 21).
1/12/76		X	The electrical generating components of the VAWT were installed.
17/12/76	X		The system was restarted.
14/1/77	X		The rotor-alternator drive chain was retensioned.
24/1/77	X		The rotor-alternator drive chain was replaced because it had stretched ($\sim$ 3/8").
31/1/77	X		The VAWT support guy cables were retensioned.
25/2/77	X		Severe ice storm was experienced. The start-up anemometer was again rendered inoperative (see Figure 22a and b).

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
3/3/77	X		The rotor-alternator drive chain was lubricated with G300 R .
21/3/77		X	The VAWT start-up control circuitry malfunctioned.
22/3/77	X		The VAWT start-up control circuitry was repaired.
25/3/77	X		The spoiler torsion spring had fatigued.
28/3/77	X		The spoiler torsion spring was replaced.
4/4/77		X	Several spoiler torsion springs had fatigued.
15/4/77	X		The malfunctioning spoiler torsion springs were replaced.
22/4/77		X	The battery capacity was low and the battery was put on charge.
27/4/77		X	Water was added to the battery cells.
28/4/77		X	The data system malfunctioned.
6/5/77	X		Malfunctioning spoiler torsion springs were replaced.
18/5/77		X	The data system was repaired, but another set of spoilers had malfunctioned.
19/5/77	X		The spoiler torsion springs were replaced.
24/5/77		X	A local electrical storm knocked out hydro power at the VAWT site. The control panel malfunction circuit was 'tripped' putting the system on a 15 amp load.
30/5/77		X	Battery was put on charge.
1/6/77	X		Battery was taken off charge.
9/6/77	X		The rotor-alternator drive chain was lubricated.
17/6/77		X	The battery capacity was low and the battery was put on charge.
21/6/77	X		The battery was taken off charge.

UNCLASSIFIED

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
11/7/77	X		The data system malfunctioned.
12/7/77		X	The battery was put on charge.
20/7/77	X		The data system was repaired.
22/7/77	X		Several spoilers had malfunctioned.
27/7/77	X		All the spoilers were replaced. It was noticed that several spoilers had been damaged during a hail storm (see Figure 20).
5/8/77	X		A local electrical storm again caused the control panel malfunction circuit to trip. This circuit was permanently disabled.
11/8/77		X	The battery capacity was very low and the battery was put on charge.
16/8/77		X	A briefing on the performance of the VAWT drive system was given. It was decided to have the drive system redesigned using timing belts and pulleys.
19/8/77	X		The battery was taken off charge.
31/8/77		X	The VAWT system was stopped and remained stopped until new drive system was installed. The battery was put on charge.
2/10/77		X	The redesign of the drive system was completed.
16/10/77		X	The data system malfunctioned. The battery was taken off charge.
25/10/77		X	The alternator and M/G were overhauled.
27/10/77		X	The data system was repaired.
16/11/77		X	The battery was discharged.
23/11/77		X	The battery was put on charge for one week.
20/12/77		X	The redesigned drive system and new support tower were installed (see Figure 15a and b).

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
22/12/77		X	The VAWT rotor was installed and drive system hook up was accomplished. The system was started, but the alternator field regulator was not working.
3/1/78		X	A fault in the field regulator was confirmed.
12/1/78	X		The field regulator was replaced with one borrowed from NRC.
28/1/78	X		The faulty regulator was repaired and reinstalled.
21/2/78		X	The battery capacity was very low and the battery was put on charge.
27/2/78	X		The battery was taken off charge.
22/3/78		X	The spoilers on one blade malfunctioned.
23/3/78	X		All the spoilers on VAWT blades were replaced with stainless steel spoilers and all torsion springs were replaced.
26/4/78	X		The alternator-M/G drive belt was replaced. This was necessary because the M/G had loosened on its mounting bracket. The resultant misalignment caused excessive wear on one side of the drive belt.
30/5/78		X	The battery capacity was low and the battery was put on charge.
1/6/78	X		The battery was taken off charge.
13/6/78		X	A short in underground hydro line caused power failure.
16/6/78	X		Temporary hydro line was installed.
18/6/78		X	A local electrical storm caused another power failure. Electrical transients resulting from lightning caused extensive damage to the VAWT start-up circuitry, strip chart recorder, power supply, DVM, and 9 track tape recorder.
22/6/78		X	Installed new data circuits.
23/6/78		X	The battery capacity was low and the battery was put on charge.

UNCLASSIFIED

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
29/6/78		X	Completed testing new data circuits and repaired start up circuitry.
30/6/78		X	The battery was taken off charge.
11/7/78	X		The system was restarted.
12/7/78	X		The alternator-M/G drive belt showed signs of wear.
13/7/78	X		The alternator-M/G drive belt was replaced and a sticking spoiler was repaired. The underground hydro line was repaired, hydro was reconnected as before and the temporary installation was removed.
17/7/78		X	The battery was put on charge.
20/7/78	X		The battery was taken off charge.
27/7/78	X		Hydro power failure occurred and the data system had to be reset.
28/7/78	X		The alternator field regulator did not appear to be functioning.
31/7/78		X	The alternator pulley assembly became loose and drive belt came off. The bore of pulley was worn but not enough to require a major repair. The battery was put on charge.
1/8/78	X		The alternator pulley assembly repaired. The battery was taken off charge.
8/8/78	X		A hydro power failure was caused by an electrical storm. The data system was reset.
9/8/78	X		The alternator definitely was not functioning properly.
10/8/78		X	The battery was put on charge and the alternator was removed for maintenance. The alternator had a shorted diode in the field regulator power supply rectifier assembly.
16/8/78	X		The alternator was repaired and reinstalled. The battery was taken off charge.

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
17/8/78	X		A hydro power failure was caused by an electrical storm. The data system was reset.
18/8/78	X		A ground post was installed and the VAWT tower was earth grounded. Lightning protectors were installed on hydro lines.
30/8/78		X	The battery was put on charge.
1/9/78	X		The battery was taken off charge.
13/9/78	X		The battery capacity was getting very low. It has become apparent that the storage battery was starting to show signs of very poor charge retension.
19/9/78		X	The battery was put on charge.
25/9/78	X		The battery was taken off charge.
19/10/78		X	The battery was put on charge.
21/10/78	X		The battery was taken off charge.
1/11/78		X	The battery was put on charge.
3/11/78	X		The battery was taken off charge.
10/11/78		X	The battery was put on charge.
17/11/78	X		The battery was taken off charge.
20/11/78		X	The alternator pulley assembly was very loose. The problem similar to that which occurred on 31/7/78, however, the mechanical wear necessitated major repair. The alternator was removed and taken to machine shop for repair. The battery was put on charge.
27/11/78	X		The repaired alternator and its pulley assembly were reinstalled. The alternator required a new bearing and the pulley assembly required a new key and keyway. The battery was taken off charge.

UNCLASSIFIED

TABLE I (Cont'd)

Date	System		Remarks
	Running	Stopped	
4/12/78	X		It was noticed that the VAWT was not starting when wind conditions were favourable. It was found that the wind speed transmitter (anemometer) cup assembly was not rotating. This was due to ice build-up on the underside of the weather flange of the cup assembly (icing condition was similar to that shown in Figure 22a&b). This problem was corrected.
18/12/78		X	The battery was completely discharged (terminal voltage was 14.8 volts). The battery was put on charge.
23/12/78		X	Data system malfunctioned.
28/12/78		X	Data system was reset.
31/12/78		X	Data system malfunctioned. The battery was kept on charge to prevent the electrolyte from freezing. Evaluation terminated.
05/10/79		X	Disassembled the VAWT. Metal fatigue fractures were seen at three of the rotor-blade mounts.

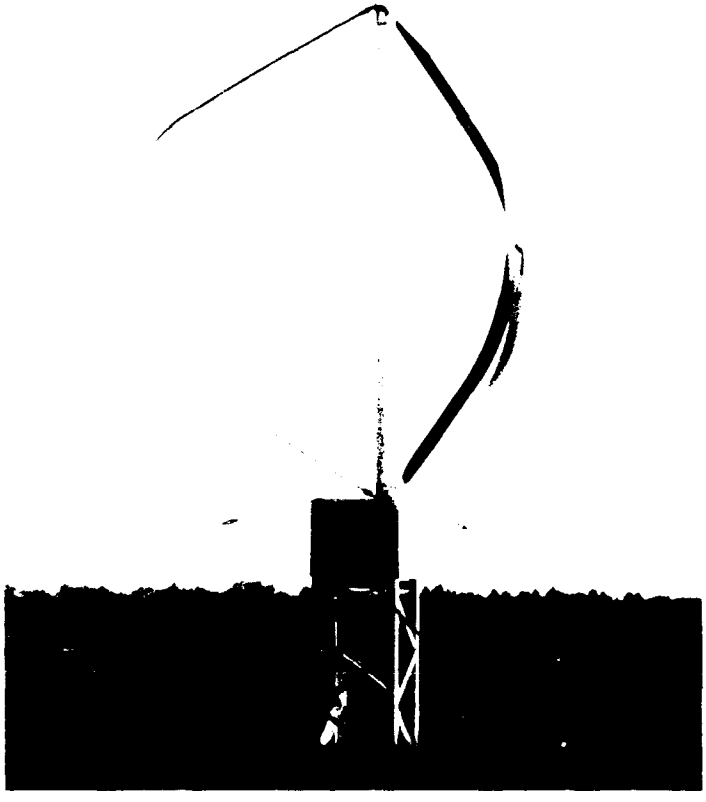


Fig. 1: VAWT installation at the CRC/DREO site.

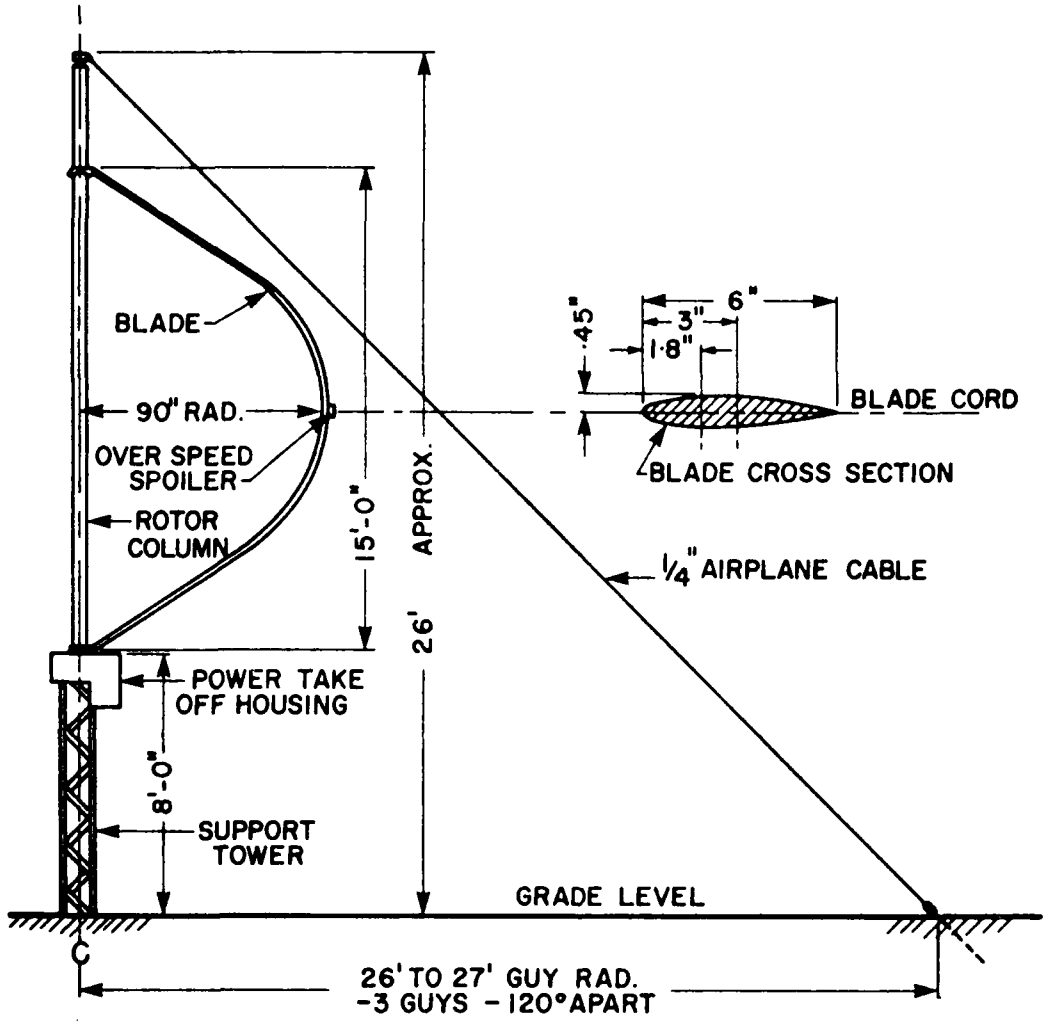


Fig. 2: NRC/DAF VAWT.

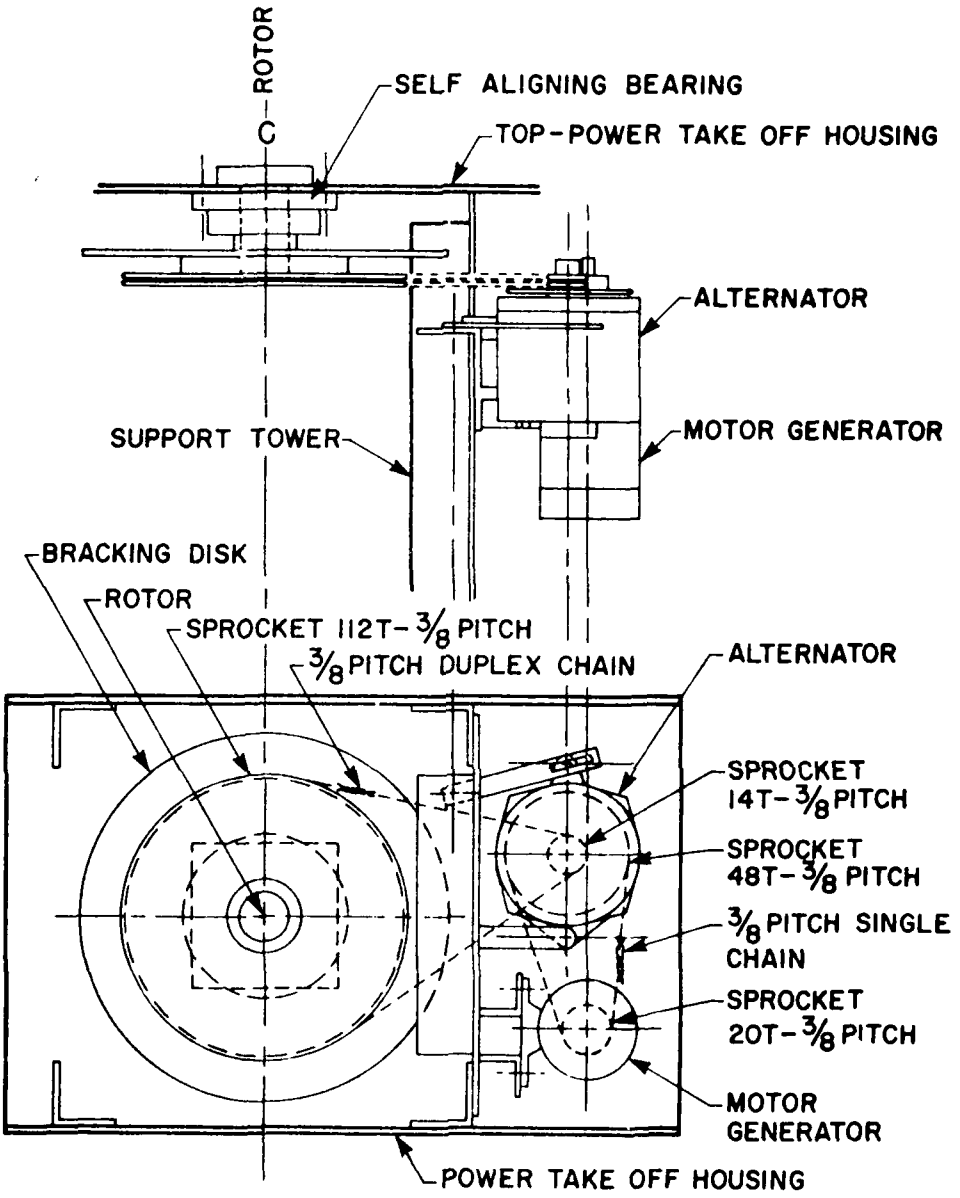


Fig. 3: Original mechanical design of electrical drive system.

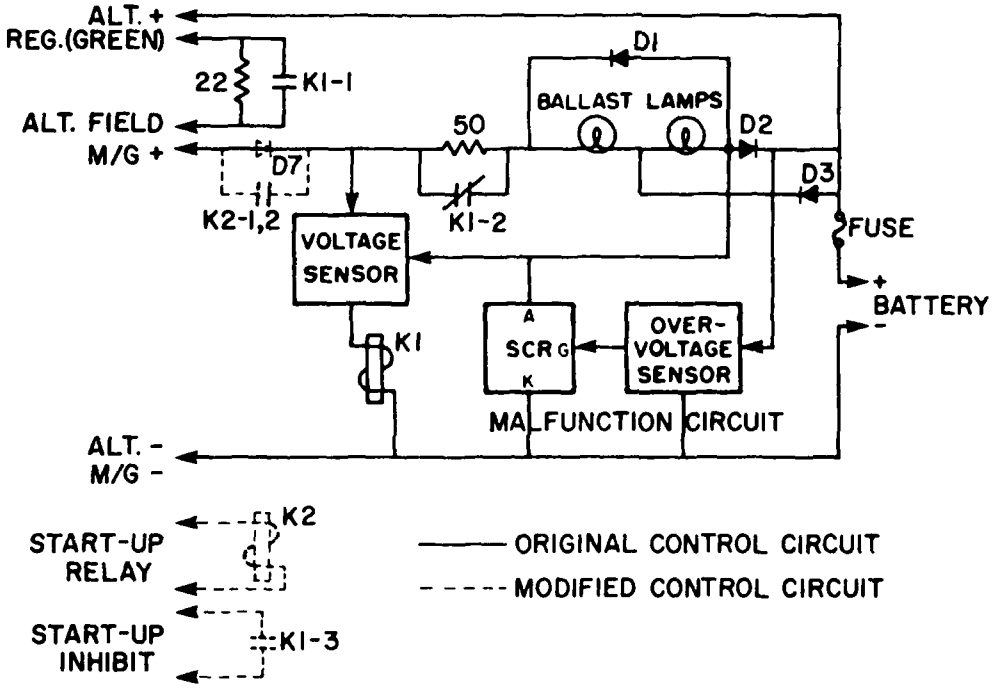


Fig. 4: Original and modified VAWT control system.

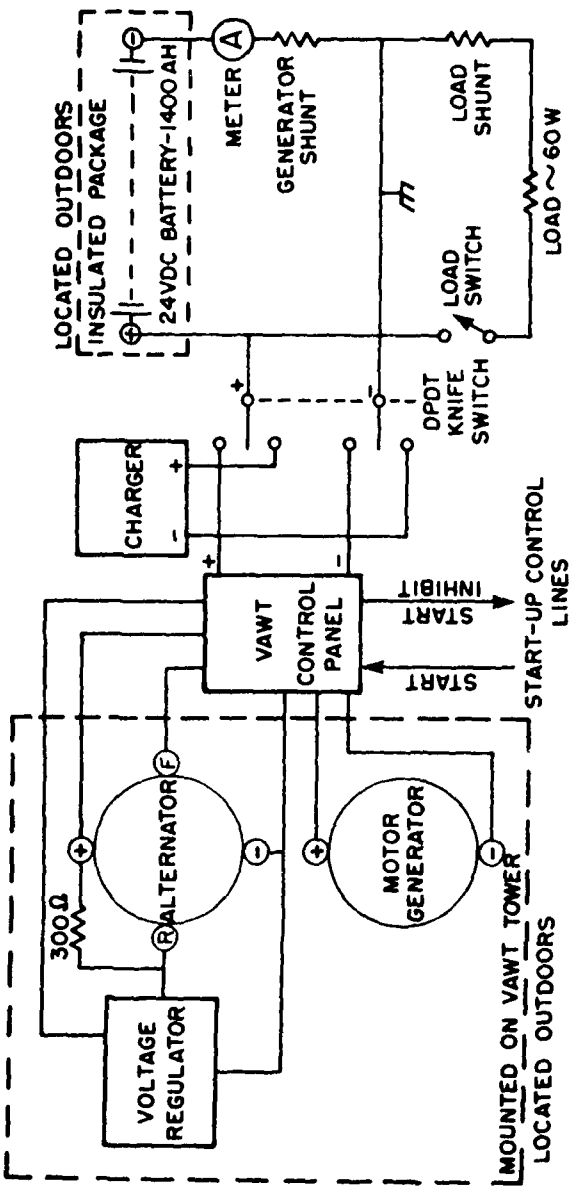


Fig. 5: Block diagram of the VAWT electrical system.

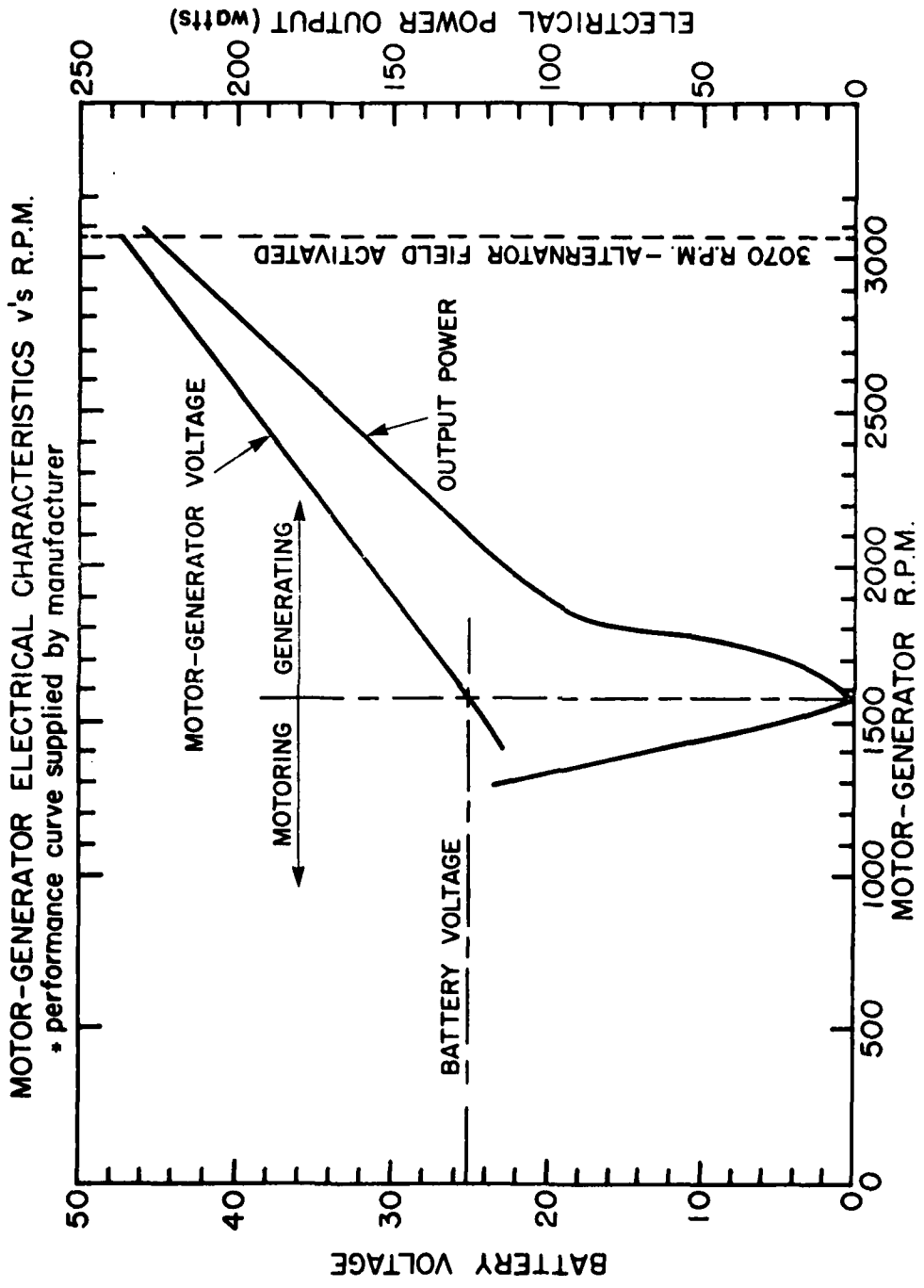


Fig. 6: Motor-Generator electrical characteristics v's RPM. (Performance curve supplied by manufacturer).

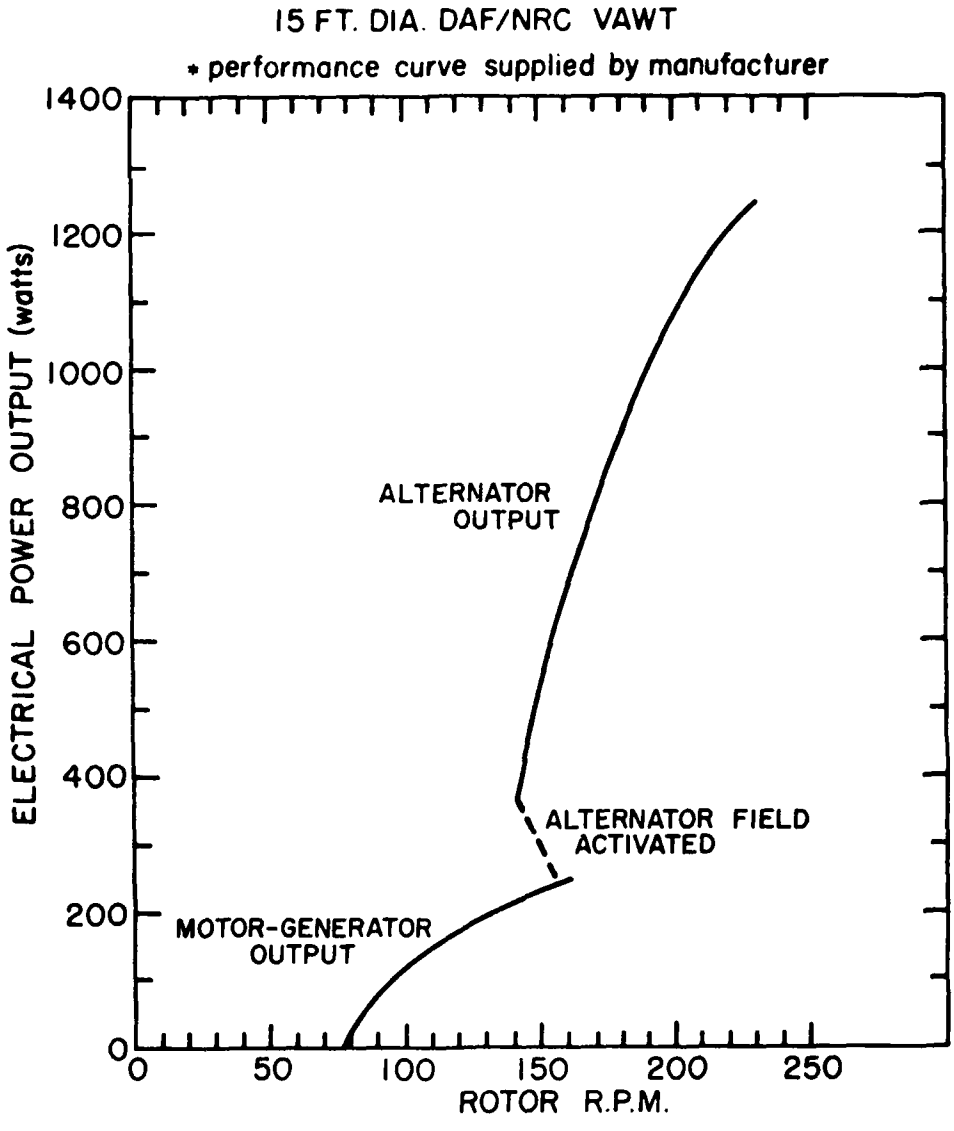


Fig. 7: VAWT power output v's rotor RPM.

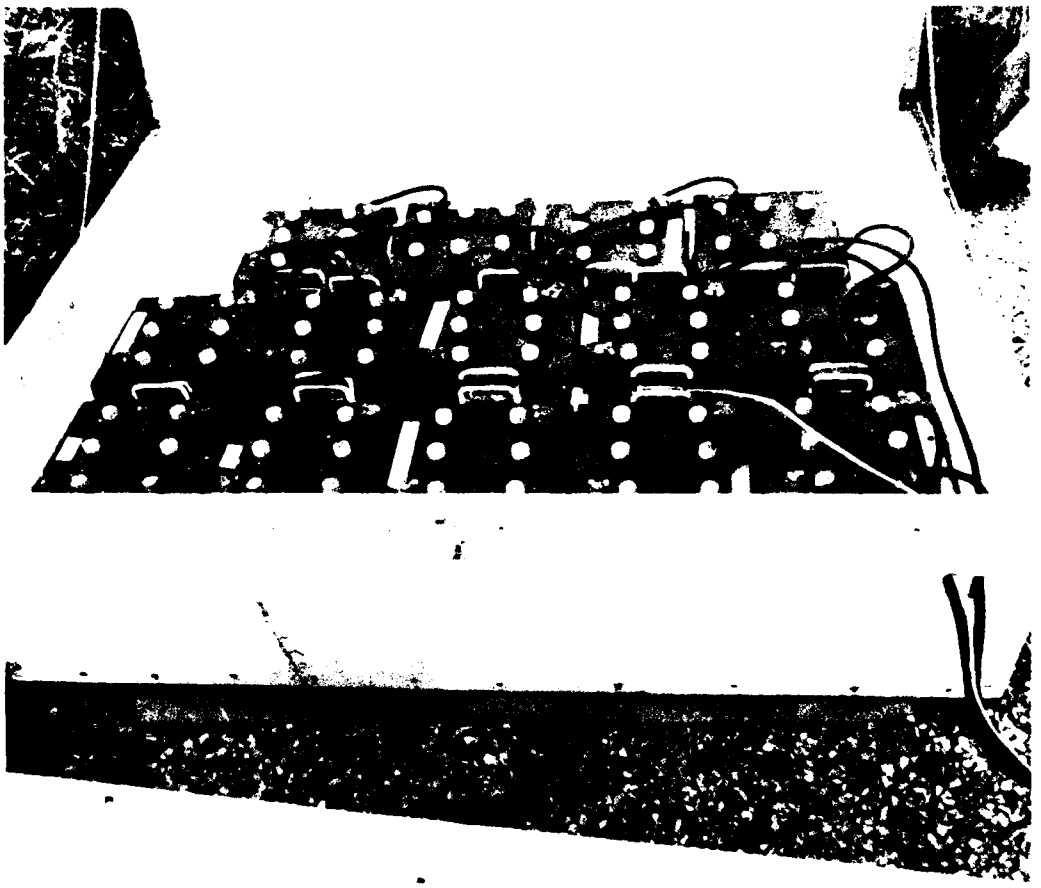
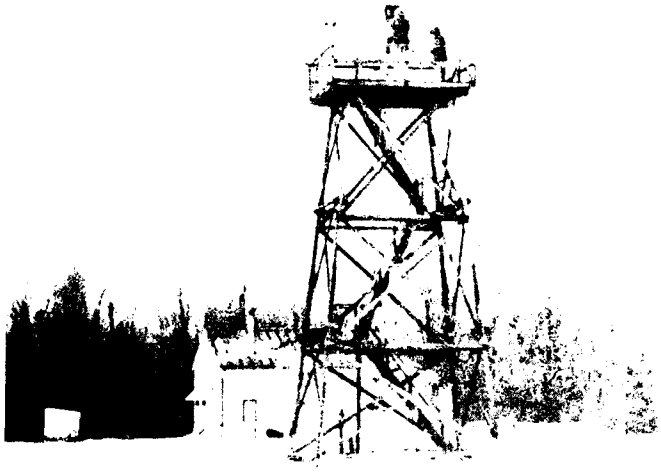


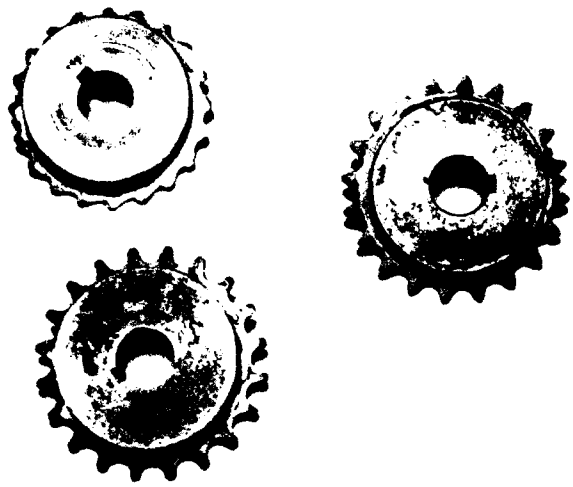
Fig. 8: Electrical storage system, one of 2 battery boxes which contains 14 - 100 Ah lead acid batteries.



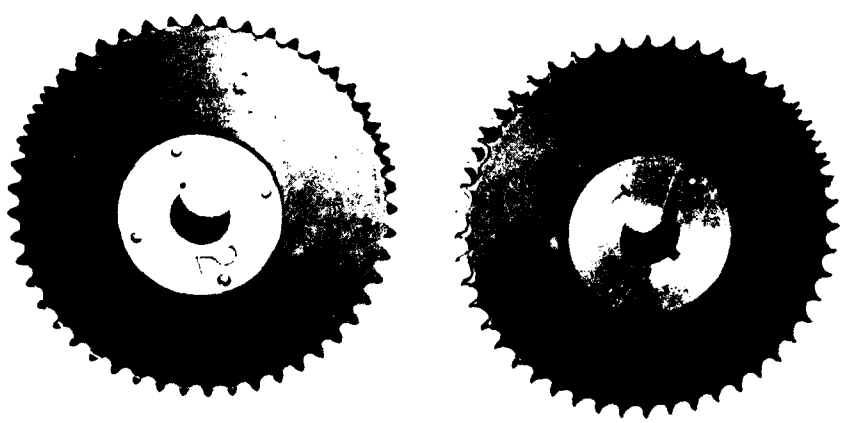
a.

b.

Fig. 9: First VAWT installation

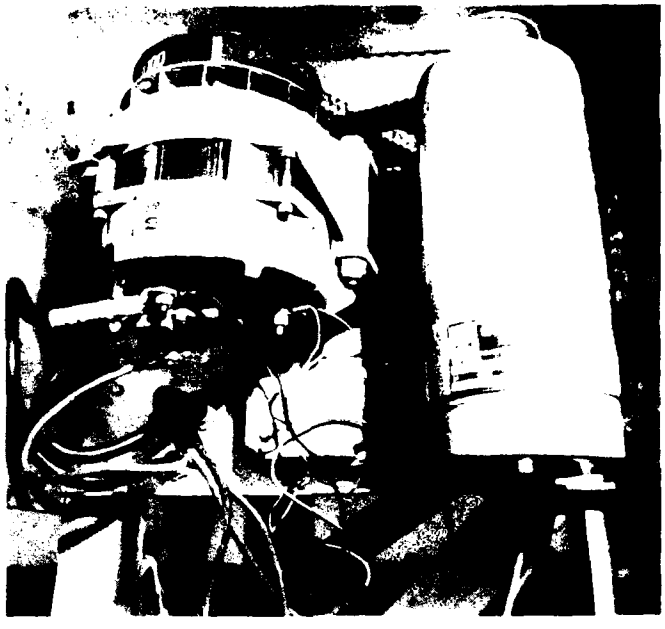


a.

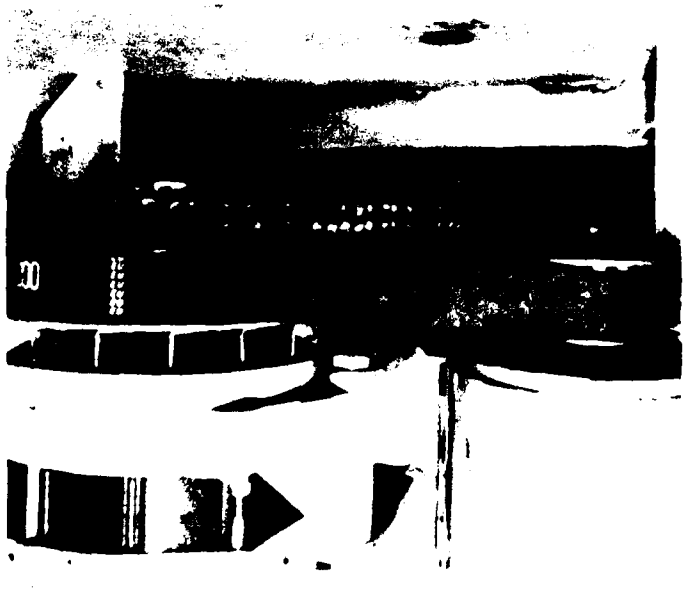


b.

Fig. 10: Photographs illustrating drive sprocket wear.



a.



b.

Fig. 11: Modification to Alternator-M/G drive system.

Fig. 12: Spoiler malfunctions.

Fig. 13: New site instrument trailer.

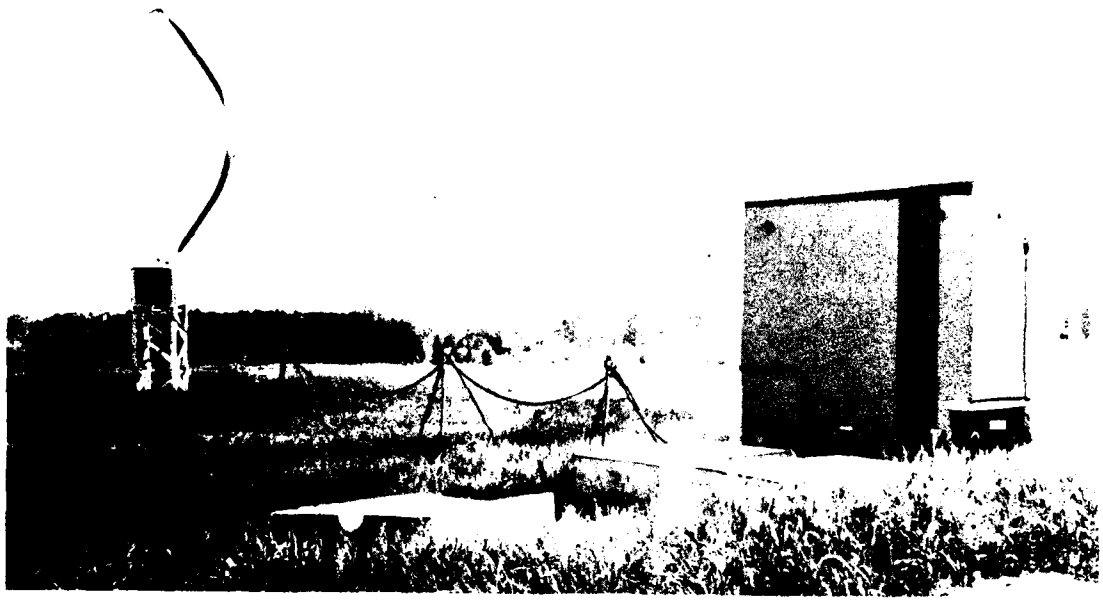


Fig. 14: New site.

Fig. 15: Redesigned electrical drive system.

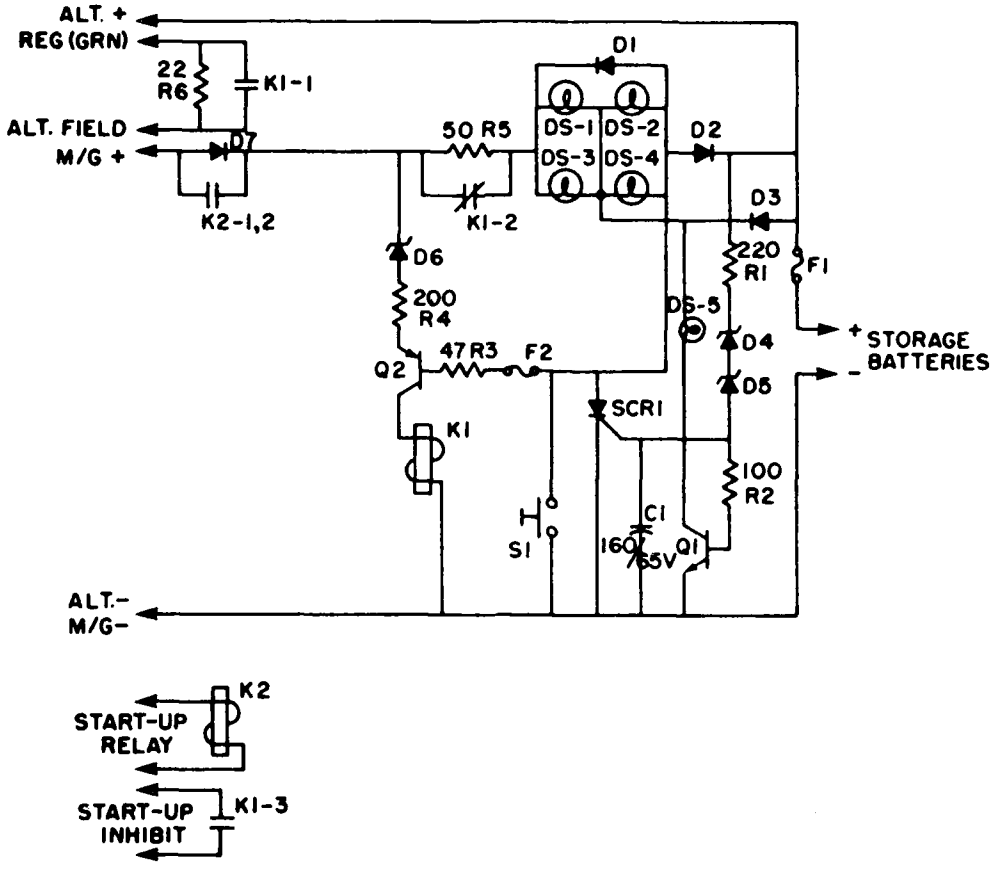


Fig. 16: Modified VAWT control circuit.

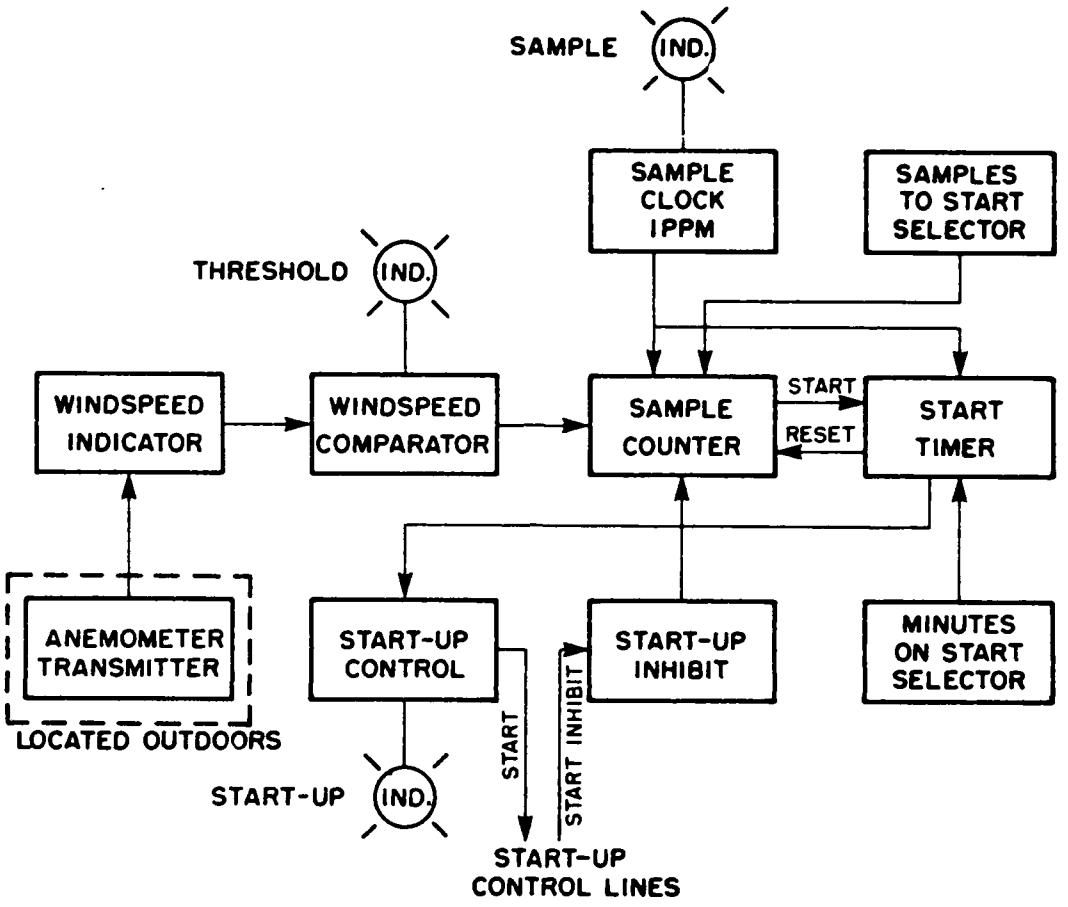


Fig. 17: Block diagram of the anemometer start-up control circuit.

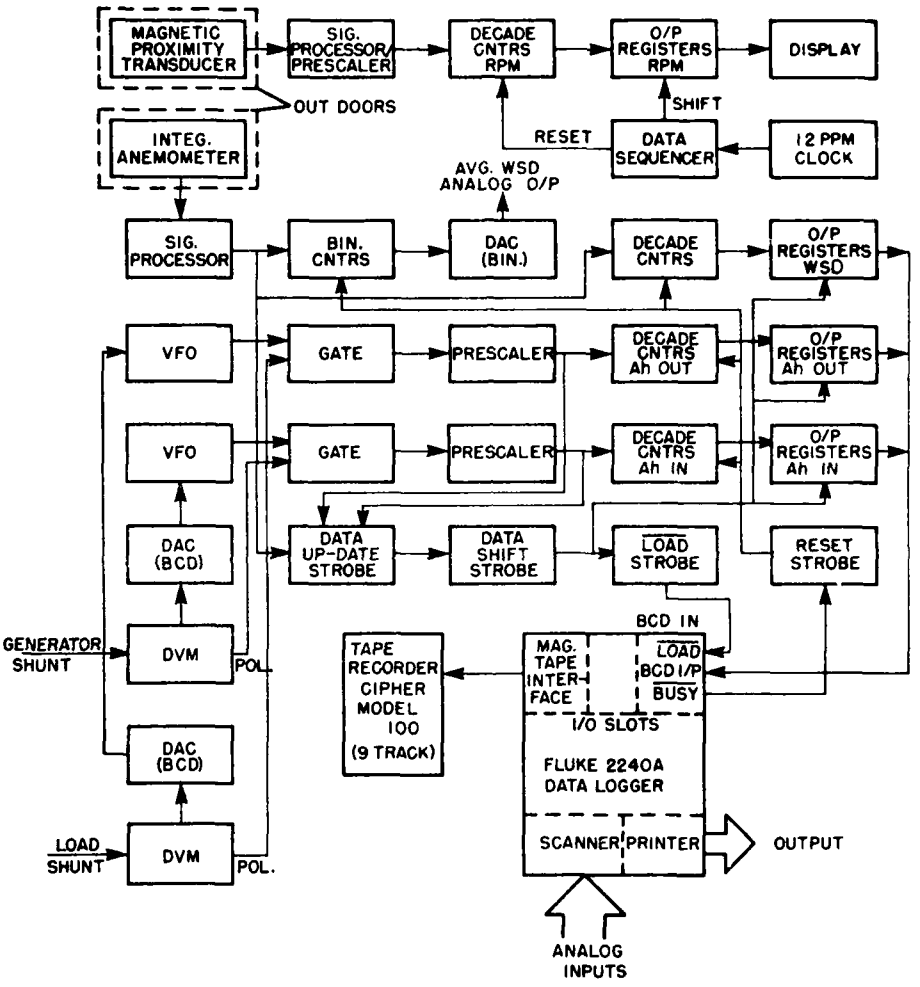


Fig. 18: Data acquisition system.

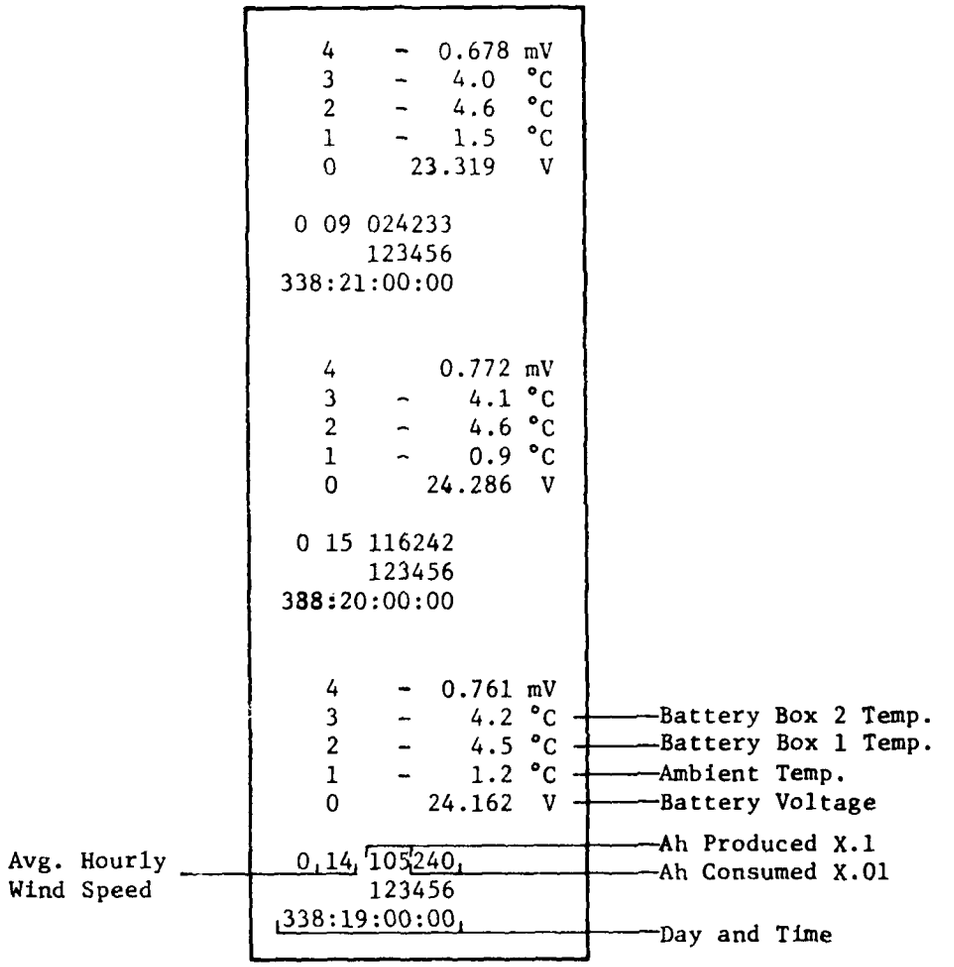


Fig. 19: Typical hourly data record.

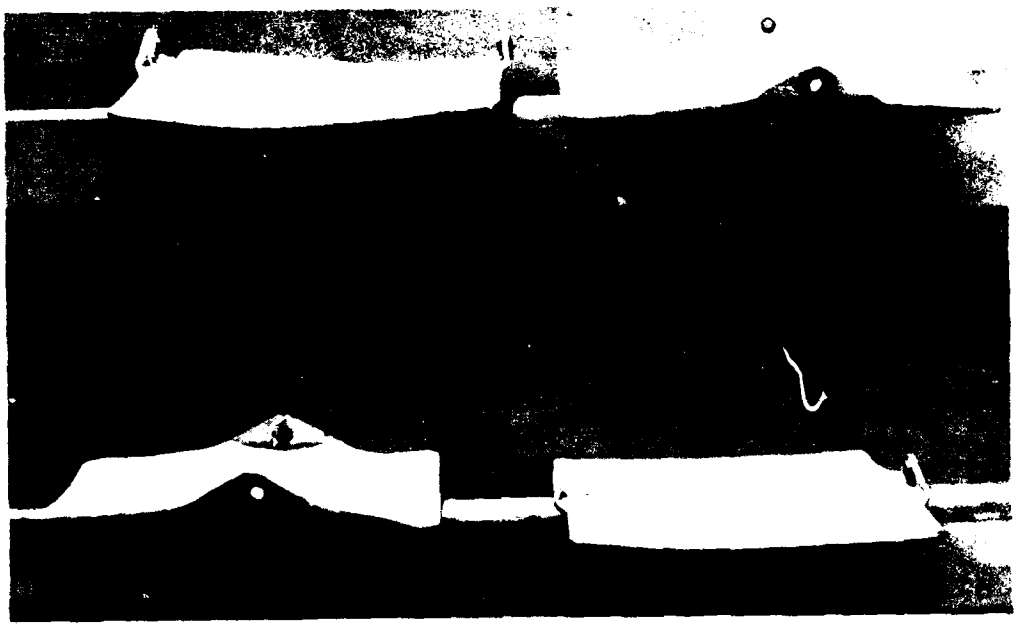


Fig. 20: Hail damage to spoilers.

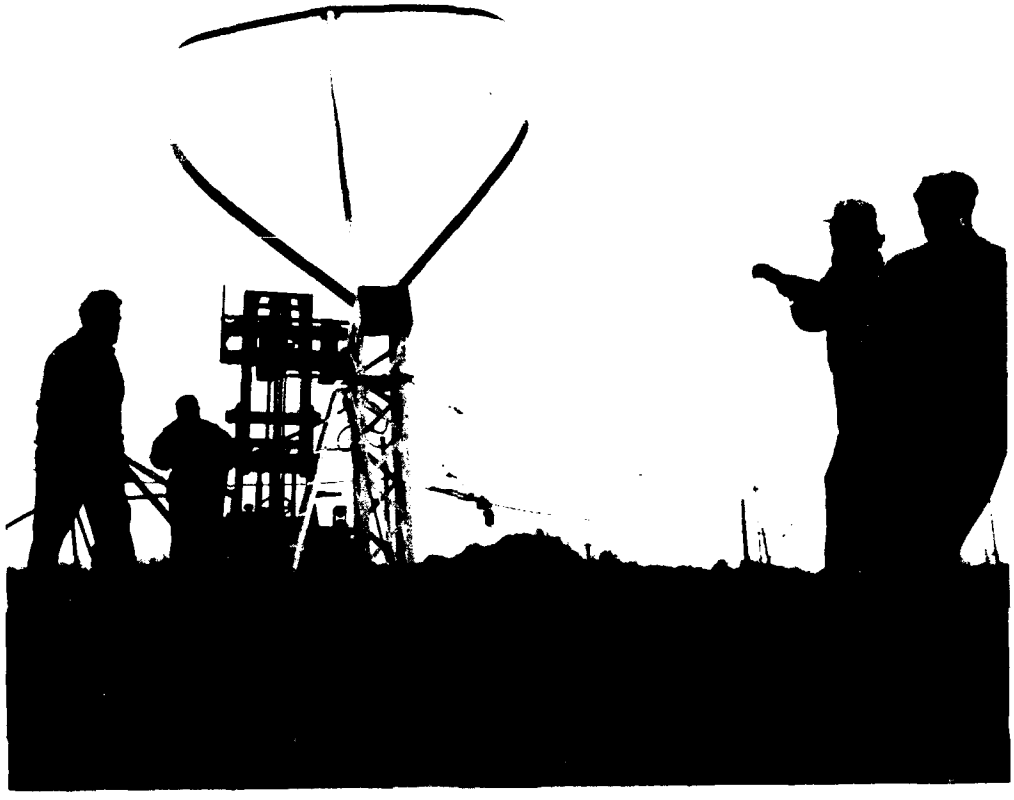
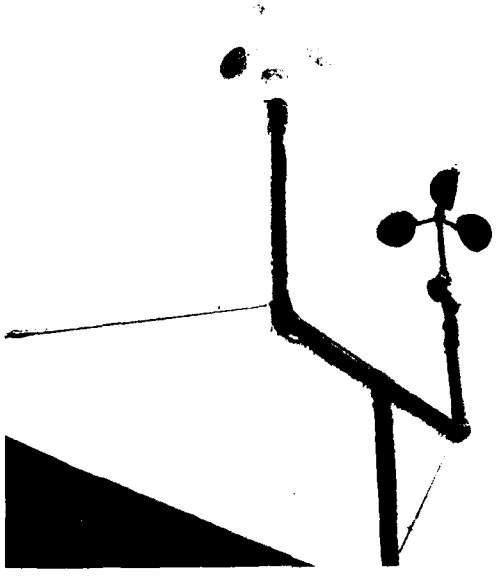
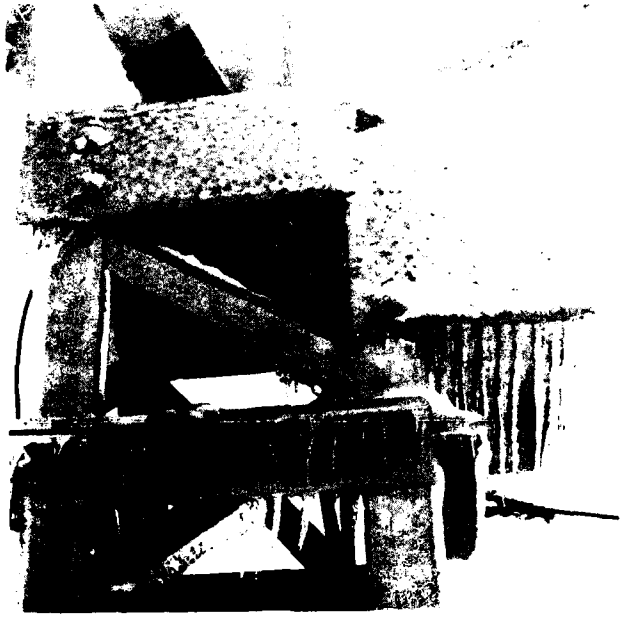


Fig. 21: Erection of VAWT at new site.



a.



b.

Fig. 22: Icing conditions encountered where the start-up anemometer and turbine spoilers were rendered inoperative.

APPENDIX A

1977 PERFORMANCE DATA SUMMARIES

SUMMARY 1977

MONTH	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	E/OUT (KWH)	E/IN (KWH)	OP (HOURS)	RUN (HOURS)	TOTAL HOURS
1.00	8.14	289.00	9999.00	47.28	58.44	744.00	374.00	744.00
2.00	7.10	201.00	9999.00	40.73	33.88	672.00	252.00	672.00
3.00	7.36	214.00	9999.00	43.43	38.13	744.00	267.00	744.00
4.00	8.50	165.00	9999.00	10.35	13.60	179.00	66.00	720.00
5.00	5.84	147.00	9999.00	37.72	22.78	575.00	199.00	744.00
6.00	5.64	124.00	9999.00	28.65	10.68	495.00	152.00	720.00
7.00	6.11	84.00	9999.00	29.14	11.03	530.00	171.00	744.00
8.00	5.13	85.00	9999.00	30.52	7.10	534.00	113.00	744.00
9.00	5.70	150.00	9999.00	0.00	0.00	0.00	0.00	720.00
10.00	5.69	118.00	9999.00	0.00	0.00	0.00	0.00	744.00
11.00	6.74	147.00	9999.00	0.00	0.00	0.00	0.00	720.00
12.00	7.35	268.00	9999.00	0.00	0.00	0.00	0.00	744.00

*****9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

AVG WSD = 6.61 MPH.....(SEE MONTHLY SUMMARY)
AVG WSD 10 MPH OR GREATER FOR 1992 HOURS.....PERCENT OF YEAR = 22.74
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY SUMMARY)
ENERGY CONSUMED = 267.82 KWH
ENERGY PRODUCED = 195.64 KWH
SYSTEM OPERATIONAL FOR 4473 HOURS.....PERCENT OF YEAR = 51.06
TURBINE RUNNING DURING 1594 HOURS.....PERCENT OF YEAR = 18.20
TOTAL HOURS IN YEAR = 8760

JANUARY 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	13.21	24.00	-11.25	27.09	62.42	1.69	134.70	3.65	24.00	24.00
2.00	6.79	9.00	-9.59	25.75	59.41	1.53	32.70	0.84	24.00	14.00
3.00	2.42	0.00	-6.77	24.92	57.54	1.43	0.00	0.00	24.00	0.00
4.00	6.08	3.00	-4.37	24.77	57.21	1.42	18.50	0.46	24.00	4.00
5.00	3.63	0.00	-10.59	24.46	56.53	1.38	4.30	0.11	24.00	7.00
6.00	5.50	3.00	-16.60	24.62	56.90	1.40	20.90	0.51	24.00	7.00
7.00	8.04	7.00	-10.58	25.01	57.77	1.44	54.30	1.36	24.00	13.00
8.00	5.58	7.00	-18.75	25.06	57.90	1.45	32.70	0.82	24.00	9.00
9.00	4.63	3.00	-20.30	24.48	56.73	1.39	15.80	0.39	24.00	8.00
10.00	14.29	18.00	-14.95	27.25	62.66	1.71	257.10	7.01	24.00	19.00
11.00	14.17	19.00	-17.49	27.68	63.68	1.76	176.50	4.89	24.00	23.00
12.00	5.58	0.00	-19.51	25.43	58.71	1.49	11.70	0.30	24.00	7.00
13.00	1.79	0.00	-21.18	25.05	57.88	1.45	0.00	0.00	24.00	0.00
14.00	7.96	3.00	-14.44	24.98	57.71	1.44	15.60	0.39	24.00	7.00
15.00	4.88	0.00	-13.93	24.72	57.11	1.41	0.90	0.02	24.00	1.00
16.00	3.29	1.00	-17.44	24.65	56.98	1.40	8.90	0.22	24.00	5.00
17.00	5.71	2.00	-24.73	24.54	56.75	1.39	11.90	0.29	24.00	6.00
18.00	10.96	15.00	-20.02	26.03	60.10	1.56	114.60	2.98	24.00	22.00
19.00	11.96	20.00	-8.85	26.08	60.12	1.57	105.10	2.74	24.00	22.00
20.00	10.63	16.00	-8.18	26.31	60.63	1.60	108.00	2.84	24.00	16.00
21.00	5.67	4.00	-12.22	25.26	58.33	1.47	22.70	0.57	24.00	9.00
22.00	10.96	15.00	9999.00	25.91	59.79	1.55	82.40	2.13	24.00	21.00
23.00	4.13	0.00	9999.00	9999.00	57.60	1.38	0.00	0.00	24.00	0.00
24.00	4.63	0.00	9999.00	24.62	56.95	1.40	0.00	0.00	24.00	0.00
25.00	14.17	19.00	-17.49	27.68	63.68	1.76	176.50	4.89	24.00	23.00
26.00	4.67	3.00	9999.00	24.37	56.29	1.37	12.50	0.30	24.00	4.00
27.00	12.29	18.00	9999.00	26.31	59.61	1.57	206.10	5.42	24.00	19.00
28.00	8.13	10.00	-15.03	25.76	59.34	1.53	83.70	2.16	24.00	13.00
29.00	12.71	23.00	-15.49	26.73	61.55	1.65	161.40	4.31	24.00	23.00
30.00	13.88	23.00	-14.35	28.01	64.42	1.80	157.00	4.40	24.00	24.00
31.00	13.96	24.00	-10.88	28.68	65.91	1.89	154.70	4.44	24.00	24.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

JANUARY 1977 (Cont'd)

AVG WSD = 8.14 *MPH*
AVG WSD 10 *MPH OR GREATER FOR* 289 *HOURS.....PERCENT OF MONTH =* 38.84
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 47.28 *KWH.....(BASED ON* 1838.21 *A-H)*
ENERGY PRODUCED = 58.44 *KWH.....(BASED ON* 2181.20 *A-H)*
SYSTEM OPERATIONAL FOR 744 *HOURS.....PERCENT OF MONTH =* 100.00
TURBINE RUNNING DURING 374 *HOURS.....PERCENT OF MONTH =* 50.27
TOTAL HOURS IN MONTH = 744

FEBRUARY 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	14.13	21.00	-12.86	28.36	65.13	1.55	124.20	3.52	24.00	21.00
2.00	3.71	0.00	-14.69	25.40	58.63	1.49	0.00	0.00	24.00	0.00
3.00	6.54	3.00	-4.56	25.40	58.57	1.49	18.30	0.46	24.00	5.00
4.00	4.75	1.00	-7.82	25.17	58.10	1.46	3.60	0.09	24.00	4.00
5.00	7.42	10.00	-11.06	25.44	58.71	1.49	52.20	1.33	24.00	13.00
6.00	13.25	24.00	-16.50	27.12	62.48	1.69	128.40	3.48	24.00	24.00
7.00	11.58	21.00	-12.97	26.90	61.98	1.67	73.20	1.97	24.00	22.00
8.00	4.83	1.00	-11.66	25.46	58.73	1.50	4.20	0.11	24.00	2.00
9.00	5.83	0.00	-5.32	24.97	57.68	1.44	0.00	0.00	24.00	0.00
10.00	2.29	0.00	-6.36	24.85	57.38	1.43	0.00	0.00	24.00	0.00
11.00	5.08	1.00	9999.00	24.78	57.25	1.42	5.10	0.13	24.00	3.00
12.00	4.00	0.00	9999.00	9999.00	57.18	1.37	5.30	0.13	24.00	3.00
13.00	8.83	8.00	9999.00	9999.00	57.52	1.38	40.30	0.97	24.00	15.00
14.00	8.63	7.00	9999.00	25.21	57.95	1.46	52.30	1.32	24.00	14.00
15.00	9.83	15.00	-13.36	25.23	58.27	1.47	64.60	1.63	24.00	19.00
16.00	5.46	2.00	-19.43	24.62	56.91	1.40	15.10	0.37	24.00	7.00
17.00	6.29	5.00	9999.00	24.48	56.95	1.39	19.10	0.47	24.00	10.00
18.00	4.29	0.00	9999.00	24.18	55.88	1.35	2.20	0.05	24.00	3.00
19.00	3.04	0.00	-5.15	24.05	55.60	1.34	0.00	0.00	24.00	0.00
20.00	3.13	0.00	-5.80	23.98	55.43	1.33	0.00	0.00	24.00	0.00
21.00	10.33	14.00	-11.96	25.19	58.17	1.47	100.00	2.52	24.00	17.00
22.00	4.58	1.00	-7.88	24.39	56.36	1.37	10.80	0.26	24.00	5.00
23.00	8.08	10.00	-12.19	24.64	56.93	1.40	85.60	2.11	24.00	11.00
24.00	9999.00	18.00	-6.05	26.05	59.98	1.56	229.00	5.96	24.00	18.00
25.00	9999.00	0.00	-0.54	24.89	57.45	1.43	0.00	0.00	24.00	0.00
26.00	5.63	2.00	-1.15	24.60	56.81	1.40	0.00	0.00	24.00	0.00
27.00	10.25	15.00	0.18	24.88	57.42	1.43	87.00	2.16	24.00	12.00
28.00	12.92	22.00	-4.42	25.89	59.70	1.55	187.00	4.84	24.00	24.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

FEBRUARY 1977 (Cont'd)

AVG WSD = 7.10 *MPH.....BASED ON* 26 *DAYS*
AVG WSD 10 *MPH OR GREATER FOR* 201 *HOURS.....PERCENT OF MONTH =* 29.91
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 40.73 *KWH.....(BASED ON* 1629.15 *A-H)*
ENERGY PRODUCED = 33.88 *KWH.....(BASED ON* 1307.50 *A-H)*
SYSTEM OPERATIONAL FOR 672 *HOURS.....PERCENT OF MONTH =* 100.00
TURBINE RUNNING DURING 252 *HOURS.....PERCENT OF MONTH =* 37.50
TOTAL HOURS IN MONTH = 672

MARCH 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	9.21	11.00	-7.33	25.36	58.51	1.48	53.30	1.35	24.00	18.00
2.00	8.75	11.00	-3.95	25.36	58.51	1.48	51.30	1.55	24.00	15.00
3.00	6.13	5.00	-1.97	24.92	57.53	1.43	19.90	0.50	24.00	10.00
4.00	9999.00	16.00	-2.80	25.47	58.75	1.50	103.20	2.63	24.00	11.00
5.00	10.67	18.00	1.85	25.56	58.94	1.51	91.70	2.34	24.00	22.00
6.00	8.29	8.00	0.35	25.32	58.40	1.48	42.00	1.06	24.00	15.00
7.00	5.33	0.00	-0.78	24.71	57.05	1.41	5.10	0.13	24.00	5.00
8.00	5.75	0.00	0.39	24.58	56.76	1.40	13.20	0.32	24.00	9.00
9.00	5.83	3.00	4.10	24.55	56.70	1.39	18.70	0.46	24.00	9.00
10.00	3.42	0.00	6.11	24.32	56.17	1.37	0.00	0.00	24.00	0.00
11.00	2.21	0.00	3.67	24.19	55.89	1.35	0.00	0.00	24.00	0.00
12.00	3.88	0.00	5.18	24.05	55.58	1.34	0.00	0.00	24.00	0.00
13.00	6.63	7.00	3.57	24.28	56.08	1.36	22.20	0.54	24.00	8.00
14.00	4.17	0.00	3.62	23.89	55.22	1.32	0.80	0.02	24.00	2.00
15.00	2.63	0.00	3.07	23.74	54.89	1.30	0.00	0.00	24.00	0.00
16.00	12.04	14.00	-2.64	24.64	56.86	1.40	181.10	4.46	24.00	16.00
17.00	14.08	18.00	-1.86	25.47	58.75	1.50	197.90	5.04	24.00	19.00
18.00	6.13	3.00	-4.35	24.72	57.06	1.41	20.80	0.51	24.00	8.00
19.00	8.29	9.00	-2.35	24.72	57.09	1.41	45.70	1.13	24.00	11.00
20.00	5.00	5.00	-1.02	24.49	56.56	1.38	23.10	0.57	24.00	8.00
21.00	4.83	1.00	0.53	24.18	55.87	1.35	4.00	0.10	24.00	4.00
22.00	10.96	15.00	9999.00	24.37	56.60	1.38	53.40	1.30	24.00	12.00
23.00	5.92	2.00	9999.00	23.91	55.77	1.33	13.00	0.31	24.00	6.00
24.00	14.42	19.00	9999.00	25.39	58.29	1.48	205.90	5.23	24.00	20.00
25.00	15.67	23.00	9999.00	25.34	59.23	1.50	131.60	3.33	24.00	14.00
26.00	7.38	5.00	-2.32	24.58	56.78	1.40	0.00	0.00	24.00	0.00
27.00	3.88	0.00	0.45	24.33	56.19	1.37	0.00	0.00	24.00	0.00
28.00	5.38	0.00	4.61	24.11	55.71	1.34	0.00	0.00	24.00	0.00
29.00	5.67	0.00	7.22	23.92	55.27	1.32	0.00	0.00	24.00	0.00
30.00	5.88	4.00	10.77	23.99	55.44	1.33	28.40	0.68	24.00	6.00
31.00	12.38	16.00	9999.00	24.70	57.07	1.41	185.20	4.57	24.00	19.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

MARCH 1977 (Cont'd)

AVG WSD = 7.36 MPH.....BASED ON 30 DAYS
AVG WSD 10 MPH OR GREATER FOR 214 HOURS.....PERCENT OF MONTH = 28.76
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 43.43 KWH.....(BASED ON 1763.50 A-H)
ENERGY PRODUCED = 38.13 KWH.....(BASED ON 1521.50 A-H)
SYSTEM OPERATIONAL FOR 744 HOURS.....PERCENT OF MONTH = 100.00
TURBINE RUNNING DURING 267 HOURS.....PERCENT OF MONTH = 35.89
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

APRIL 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	6.67	5.00	1.34	24.49	56.58	1.39	21.00	0.51	24.00	11.00
2.00	9.00	16.00	0.80	24.84	57.43	1.43	98.70	2.45	24.00	17.00
3.00	16.79	15.00	3.72	26.00	60.00	1.56	357.30	9.29	24.00	18.00
4.00	10.50	14.00	9999.00	25.10	26.64	0.67	1.60	0.04	11.00	2.00
5.00	11.38	18.00	9999.00	24.73	0.00	0.00	0.00	0.00	0.00	0.00
6.00	16.46	23.00	9999.00	24.48	0.00	0.00	0.00	0.00	0.00	0.00
7.00	6.58	4.00	-2.87	24.28	0.00	0.00	0.00	0.00	0.00	0.00
8.00	14.08	16.00	-6.78	24.09	0.00	0.00	0.00	0.00	0.00	0.00
9.00	6.75	7.00	-3.22	23.90	0.00	0.00	0.00	0.00	0.00	0.00
10.00	2.88	0.00	2.70	23.76	0.00	0.00	0.00	0.00	0.00	0.00
11.00	8.13	8.00	11.78	23.64	0.00	0.00	0.00	0.00	0.00	0.00
12.00	5.50	1.00	13.20	23.56	0.00	0.00	0.00	0.00	0.00	0.00
13.00	4.88	5.00	9999.00	23.45	0.00	0.00	0.00	0.00	0.00	0.00
14.00	10.00	14.00	9999.00	24.22	0.00	0.00	0.00	0.00	0.00	0.00
15.00	8.08	9.00	9999.00	24.74	32.93	0.81	43.50	1.08	14.00	7.00
16.00	6.88	8.00	9999.00	24.07	55.62	1.34	9.20	0.22	24.00	9.00
17.00	5.08	1.00	9999.00	23.77	55.05	1.31	0.50	0.01	24.00	2.00
18.00	3.29	0.00	9999.00	23.61	54.98	1.30	0.00	0.00	24.00	0.00
19.00	9999.00	9999.00	9999.00	9999.00	23.00	0.54	0.00	0.00	10.00	0.00
20.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
21.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
22.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
23.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
24.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
26.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
27.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
28.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
29.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
30.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

APRIL 1977 (Cont'd)

AVG WSD = 8.50 MPH.....BASED ON 18 DAYS
AVG WSD 10 MPH OR GREATER FOR = 165 HOURS (SEE MONTHLY LOG).....PERCENT OF MONTH = 22.92
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 10.35 KWH.....(BASED ON 422.23 A-H)
ENERGY PRODUCED = 13.60 KWH.....(BASED ON 531.80 A-H)
SYSTEM OPERATIONAL FOR 179 HOURS.....PERCENT OF MONTH = 24.86
TURBINE RUNNING DURING 66 HOURS.....PERCENT OF MONTH = 9.17
TOTAL HOURS IN MONTH = 720

MAY 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	9999.00	14.00	9999.00	9999.00	32.20	0.77	201.00	4.82	14.00	14.00
7.00	9.50	15.00	9999.00	9999.00	55.20	1.32	72.80	1.75	24.00	19.00
8.00	7.54	7.00	9999.00	9999.00	52.20	1.32	61.20	1.47	24.00	10.00
9.00	12.04	19.00	9999.00	9999.00	55.20	1.32	127.00	3.05	24.00	20.00
10.00	9.54	12.00	9999.00	9999.00	55.20	1.32	62.10	1.49	24.00	16.00
11.00	7.25	7.00	9999.00	9999.00	55.20	1.32	43.50	1.04	24.00	9.00
12.00	5.38	0.00	9999.00	9999.00	55.20	1.32	3.60	0.09	24.00	5.00
13.00	11.25	17.00	9999.00	9999.00	55.20	1.32	131.20	3.15	24.00	17.00
14.00	9.00	12.00	9999.00	9999.00	55.20	1.32	56.70	1.36	24.00	15.00
15.00	5.67	1.00	9999.00	9999.00	55.20	1.32	0.30	0.01	24.00	2.00
16.00	6.67	4.00	9999.00	9999.00	55.20	1.32	11.10	0.27	24.00	11.00
17.00	8.50	11.00	9999.00	9999.00	55.20	1.32	46.40	1.11	24.00	14.00
18.00	3.33	1.00	9999.00	24.87	55.57	1.38	4.30	0.11	24.00	5.00
19.00	0.88	0.00	9999.00	24.76	55.37	1.40	0.00	0.00	24.00	0.00
20.00	1.38	0.00	20.81	24.69	57.05	1.41	0.00	0.00	24.00	0.00
21.00	4.46	1.00	24.52	24.61	56.87	1.40	3.60	0.09	24.00	3.00
22.00	4.83	4.00	25.15	24.63	56.91	1.40	16.40	0.40	24.00	6.00
23.00	3.92	3.00	9999.00	24.53	159.18	3.91	4.00	0.10	24.00	3.00
24.00	3.08	0.00	9999.00	23.91	187.56	4.48	0.00	0.00	24.00	0.00
25.00	9.13	13.00	19.59	24.30	56.19	1.37	57.70	1.40	24.00	16.00
26.00	5.67	1.00	17.32	23.88	55.26	1.32	7.50	0.18	24.00	5.00
27.00	3.17	0.00	17.94	23.68	54.79	1.30	0.00	0.00	24.00	0.00
28.00	4.75	5.00	10.49	23.70	54.84	1.30	16.20	0.38	24.00	7.00
29.00	3.83	0.00	14.00	23.43	54.22	1.27	0.40	0.01	24.00	2.00
30.00	2.08	0.00	9999.00	24.31	20.25	0.49	0.00	0.00	9.00	0.00
31.00	3.04	0.00	21.72	25.64	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

MAY 1977 (Cont'd)

AVG WSD = 5.84 MPH.....BASED ON 25 DAYS
AVG WSD 10 MPH OR GREATER FOR = 147 HOURS (SEE MONTHLY LOG).....PERCENT OF MONTH = 19.76
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 37.72 KWH.....(BASED ON 1561.46 A-H)
ENERGY PRODUCED = 22.28 KWH.....(BASED ON 927.00 A-H)
SYSTEM OPERATIONAL FOR 575 HOURS.....PERCENT OF MONTH = 77.28
TURBINE RUNNING DURING 199 HOURS.....PERCENT OF MONTH = 26.75
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

JUNE 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	7.13	8.00	20.12	25.58	38.90	1.00	31.00	0.79	16.00	10.00
2.00	7.17	8.00	11.84	25.06	57.89	1.45	33.10	0.83	24.00	10.00
3.00	5.21	5.00	12.18	24.18	57.81	1.42	19.30	0.48	24.00	8.00
4.00	4.96	1.00	15.97	24.55	56.75	1.39	3.80	0.09	24.00	4.00
5.00	9.54	12.00	9999.00	24.65	56.01	1.38	42.80	1.05	24.00	14.00
6.00	8.38	8.00	9999.00	24.75	56.44	1.40	31.60	0.78	24.00	16.00
7.00	9.67	13.00	8.69	24.82	57.36	1.42	43.90	1.09	24.00	17.00
8.00	9.29	12.00	8.17	24.77	57.24	1.42	53.20	1.32	24.00	19.00
9.00	4.50	1.00	13.19	24.23	23.39	0.57	0.00	0.00	10.00	0.00
10.00	4.70	1.00	16.24	24.11	0.00	0.00	0.00	0.00	0.00	0.00
11.00	4.42	2.00	18.69	24.00	0.00	0.00	0.00	0.00	0.00	0.00
12.00	5.13	3.00	17.62	23.87	0.00	0.00	0.00	0.00	0.00	0.00
13.00	3.79	0.00	19.17	23.74	0.00	0.00	0.00	0.00	0.00	0.00
14.00	2.04	0.00	9999.00	23.60	0.00	0.00	0.00	0.00	0.00	0.00
15.00	3.88	0.00	19.67	23.46	31.64	0.74	0.70	0.02	14.00	4.00
16.00	3.38	0.00	21.25	23.31	53.95	1.26	0.00	0.00	24.00	0.00
17.00	4.83	0.00	18.98	23.65	54.71	1.29	0.00	0.00	24.00	0.00
18.00	6.00	1.00	15.44	24.97	23.85	0.60	0.00	0.00	10.00	0.00
19.00	7.25	7.00	19.01	25.59	0.00	0.00	0.00	0.00	0.00	0.00
20.00	5.50	0.00	18.71	26.25	0.00	0.00	0.00	0.00	0.00	0.00
21.00	7.50	10.00	17.25	26.14	32.03	0.84	32.50	0.85	13.00	9.00
22.00	5.67	2.00	15.72	25.12	58.00	1.46	10.00	0.25	24.00	5.00
23.00	3.58	0.00	19.62	24.78	57.22	1.42	0.00	0.00	24.00	0.00
24.00	3.88	1.00	20.22	24.56	56.73	1.39	3.40	0.08	24.00	2.00
25.00	2.71	0.00	17.97	24.38	56.34	1.37	0.00	0.00	24.00	0.00
26.00	2.96	0.00	22.31	24.26	56.07	1.36	0.00	0.00	24.00	0.00
27.00	3.67	0.00	24.79	24.15	55.82	1.35	0.00	0.00	24.00	0.00
28.00	4.96	3.00	25.12	24.14	55.81	1.35	19.40	0.47	24.00	0.00
29.00	7.92	11.00	19.97	24.23	55.99	1.36	33.50	0.81	24.00	14.00
30.00	9.46	15.00	9999.00	24.78	56.81	1.41	71.60	1.77	24.00	20.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

JUNE 1977 (Cont'd)

AVG WSD = 5.64 MPH
AVG WSD 10 MPH OR GREATER FOR 124 HOURS.....PERCENT OF MONTH = 17.22
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 28.65 KWH.....(BASED ON 1166.76 A-H)
ENERGY PRODUCED = 10.68 KWH.....(BASED ON 429.80 A-H)
SYSTEM OPERATIONAL FOR 495 HOURS.....PERCENT OF MONTH = 68.75
TURBINE RUNNING DURING 152 HOURS.....PERCENT OF MONTH = 21.11
TOTAL HOURS IN MONTH = 720

JULY 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	9.79	11.00	9999.00	9999.00	55.20	1.32	57.00	1.37	24.00	16.00
2.00	8.63	10.00	9999.00	9999.00	55.20	1.32	43.90	1.05	24.00	19.00
3.00	4.75	0.00	9999.00	9999.00	55.20	1.32	5.50	0.13	24.00	4.00
4.00	5.25	1.00	9999.00	23.94	55.25	1.32	8.90	0.21	24.00	6.00
5.00	4.67	3.00	9999.00	23.94	55.27	1.32	16.10	0.39	24.00	7.00
6.00	2.08	0.00	9999.00	23.50	54.75	1.29	0.00	0.00	24.00	0.00
7.00	5.38	0.00	9999.00	23.35	55.00	1.28	1.60	0.04	24.00	1.00
8.00	4.54	0.00	9999.00	23.20	53.87	1.25	0.00	0.00	24.00	0.00
9.00	9999.00	3.00	9999.00	23.15	53.51	1.24	25.20	0.58	24.00	9.00
10.00	9999.00	0.00	9999.00	9999.00	52.80	1.27	0.00	0.00	24.00	0.00
11.00	9999.00	0.00	9999.00	22.84	30.80	0.70	0.00	0.00	14.00	0.00
12.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
13.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
14.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
16.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
17.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
18.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
19.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	7.00	5.00	9999.00	9999.00	28.80	0.69	22.00	0.53	12.00	7.00
21.00	7.11	6.00	9999.00	9999.00	57.60	1.38	38.60	0.93	24.00	12.00
22.00	8.29	13.00	9999.00	9999.00	57.60	1.38	46.70	1.12	24.00	13.00
23.00	4.58	0.00	9999.00	9999.00	56.40	1.35	1.70	0.04	24.00	3.00
24.00	4.42	0.00	9999.00	9999.00	56.40	1.35	6.40	0.15	24.00	6.00
25.00	10.13	13.00	9999.00	9999.00	56.40	1.35	64.70	1.55	24.00	14.00
26.00	8.96	10.00	9999.00	9999.00	56.40	1.35	61.40	1.47	24.00	19.00
27.00	5.63	2.00	9999.00	9999.00	56.40	1.35	6.90	0.17	24.00	6.00
28.00	4.75	1.00	9999.00	9999.00	56.40	1.35	10.00	0.24	24.00	5.00
29.00	5.83	3.00	9999.00	9999.00	55.20	1.32	19.30	0.46	24.00	11.00
30.00	6.00	3.00	9999.00	9999.00	55.20	1.32	17.20	0.42	24.00	8.00
31.00	4.50	0.00	9999.00	9999.00	55.20	1.32	7.40	0.18	24.00	5.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

JULY 1977 (Cont'd)

AVG WSD = 6.11 MPH.....BASED ON 20 DAYS
AVG WSD 10 MPH OR GREATER FOR = 84 HOURS (SEE MONTHLY LOG).....PERCENT OF MONTH = 11.29
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 29.14 KWH.....(BASED ON 1224.85 A-H)
ENERGY PRODUCED = 11.03 KWH.....(BASED ON 460.50 A-H)
SYSTEM OPERATIONAL FOR 530 HOURS.....PERCENT OF MONTH = 71.24
TURBINE RUNNING DURING 171 HOURS.....PERCENT OF MONTH = 22.98
TOTAL HOURS IN MONTH = 744

AUGUST 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	4.92	3.00	9999.00	9999.00	55.20	1.32	19.50	0.47	24.00	7.00
2.00	3.67	0.00	9999.00	24.30	55.20	1.34	0.90	0.02	24.00	2.00
3.00	2.79	0.00	9999.00	9999.00	55.20	1.32	0.00	0.00	24.00	0.00
4.00	5.13	5.00	9999.00	24.10	55.20	1.33	27.40	0.66	24.00	7.00
5.00	3.83	0.00	9999.00	9999.00	55.20	1.32	0.10	0.00	24.00	1.00
6.00	4.92	0.00	9999.00	9999.00	55.20	1.32	4.10	0.10	24.00	3.00
7.00	2.67	0.00	9999.00	9999.00	55.20	1.32	0.00	0.00	24.00	0.00
8.00	4.29	0.00	9999.00	9999.00	55.20	1.32	2.90	0.07	24.00	3.00
9.00	5.04	0.00	9999.00	9999.00	55.20	1.32	1.50	0.04	24.00	3.00
10.00	6.04	1.00	9999.00	9999.00	55.20	1.32	14.80	0.36	24.00	6.00
11.00	4.33	0.00	9999.00	9999.00	20.20	0.48	0.00	0.00	10.00	0.00
12.00	4.75	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
13.00	6.50	6.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
14.00	5.83	5.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	3.13	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
16.00	4.13	3.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
17.00	6.00	2.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
18.00	9.25	11.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
19.00	4.17	1.00	9999.00	9999.00	21.60	0.52	0.00	0.00	9.00	0.00
20.00	5.63	1.00	9999.00	9999.00	57.60	1.38	18.20	0.44	24.00	9.00
21.00	4.58	3.00	9999.00	9999.00	57.60	1.38	20.60	0.49	24.00	6.00
22.00	8.00	10.00	9999.00	25.54	57.60	1.37	44.70	1.14	24.00	11.00
23.00	7.71	8.00	16.85	25.40	58.61	1.49	34.10	0.87	24.00	11.00
24.00	4.88	0.00	14.94	25.01	57.74	1.44	1.70	0.04	24.00	4.00
25.00	5.42	3.00	13.45	24.92	57.55	1.43	6.00	0.15	24.00	3.00
26.00	4.04	1.00	9999.00	24.82	37.33	1.42	4.60	0.11	24.00	5.00
27.00	4.95	5.00	21.18	24.85	57.36	1.43	15.40	0.38	24.00	7.00
28.00	7.54	9.00	26.67	25.05	57.85	1.45	37.40	0.94	24.00	14.00
29.00	7.58	8.00	23.57	24.91	57.52	1.43	3.19	0.79	24.00	10.00
30.00	3.79	0.00	9999.00	24.63	56.88	1.40	1.20	0.03	24.00	1.00
31.00	3.63	0.00	9999.00	25.72	26.07	0.67	0.00	0.00	11.00	0.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

AUGUST 1977 (Cont'd)

AVG WSD = 5.13 *MPH*
AVG WSD 10 *MPH OR GREATER FOR* 85 *HOURS.....PERCENT OF MONTH =* 11.42
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 30.52 *KWH.....(BASED ON* 1233.51 *A-H)*
ENERGY PRODUCED = 7.10 *KWH.....(BASED ON* 258.29 *A-H)*
SYSTEM OPERATIONAL FOR 534 *HOURS.....PERCENT OF MONTH =* 71.77
TURBINE RUNNING DURING 113 *HOURS.....PERCENT OF MONTH =* 15.19
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

SEPTEMBER 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	6.33	6.00	9999.00	26.40	0.00	0.00	0.00	0.00	0.00	0.00
2.00	2.75	0.00	9999.00	27.38	0.00	0.00	0.00	0.00	0.00	0.00
3.00	5.17	2.00	9999.00	27.88	0.00	0.00	0.00	0.00	0.00	0.00
4.00	2.88	0.00	9999.00	28.02	0.00	0.00	0.00	0.00	0.00	0.00
5.00	4.42	2.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	4.71	1.00	9999.00	25.74	0.00	0.00	0.00	0.00	0.00	0.00
7.00	3.21	0.00	11.78	25.66	0.00	0.00	0.00	0.00	0.00	0.00
8.00	2.46	0.00	9999.00	25.62	0.00	0.00	0.00	0.00	0.00	0.00
9.00	9.38	12.00	9999.00	25.59	0.00	0.00	0.00	0.00	0.00	0.00
10.00	11.42	18.00	9999.00	25.59	0.00	0.00	0.00	0.00	0.00	0.00
11.00	7.96	10.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
12.00	2.50	0.00	9999.00	25.55	0.00	0.00	0.00	0.00	0.00	0.00
13.00	4.67	0.00	14.46	25.54	0.00	0.00	0.00	0.00	0.00	0.00
14.00	8.00	10.00	9999.00	25.54	0.00	0.00	0.00	0.00	0.00	0.00
15.00	2.25	0.00	9999.00	25.52	0.00	0.00	0.00	0.00	0.00	0.00
16.00	3.79	0.00	9999.00	25.51	0.00	0.00	0.00	0.00	0.00	0.00
17.00	3.50	0.00	15.41	25.51	0.00	0.00	0.00	0.00	0.00	0.00
18.00	1.50	0.00	17.31	25.50	0.00	0.00	0.00	0.00	0.00	0.00
19.00	5.08	3.00	16.00	25.50	0.00	0.00	0.00	0.00	0.00	0.00
20.00	15.71	24.00	7.45	25.48	0.00	0.00	0.00	0.00	0.00	0.00
21.00	8.79	13.00	7.57	25.46	0.00	0.00	0.00	0.00	0.00	0.00
22.00	3.08	0.00	10.31	25.46	0.00	0.00	0.00	0.00	0.00	0.00
23.00	2.58	0.00	12.17	25.46	0.00	0.00	0.00	0.00	0.00	0.00
24.00	8.08	13.00	11.50	25.45	0.00	0.00	0.00	0.00	0.00	0.00
25.00	8.88	8.00	9.05	25.44	0.00	0.00	0.00	0.00	0.00	0.00
26.00	7.92	7.00	11.76	25.44	0.00	0.00	0.00	0.00	0.00	0.00
27.00	10.08	17.00	14.36	25.43	0.00	0.00	0.00	0.00	0.00	0.00
28.00	4.58	1.00	11.20	25.43	0.00	0.00	0.00	0.00	0.00	0.00
29.00	5.92	3.00	8.55	25.42	0.00	0.00	0.00	0.00	0.00	0.00
30.00	3.29	0.00	8.88	25.41	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

SEPTEMBER 1977 (Cont'd)

AVG WSD = 5.70 MPH
AVG WSD 10 MPH OR GREATER FOR 150 HOURS.....PERCENT OF MONTH = 20.83
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 0.00 KWH.....(BASED ON 0.00 A-H)
ENERGY PRODUCED = 0.00 KWH.....(BASED ON 0.00 A-H)
SYSTEM OPERATIONAL FOR 0 HOURS.....PERCENT OF MONTH = 0.00
TURBINE RUNNING DURING 0 HOURS.....PERCENT OF MONTH = 0.00
TOTAL HOURS IN MONTH = 720

UNCLASSIFIED

OCTOBER 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	8.46	13.00	8.31	25.40	0.00	0.00	0.00	0.00	0.00	0.00
2.00	6.50	0.00	9999.00	25.40	0.00	0.00	0.00	0.00	0.00	0.00
3.00	7.13	5.00	9999.00	25.38	0.00	0.00	0.00	0.00	0.00	0.00
4.00	8.25	8.00	9.04	25.38	0.00	0.00	0.00	0.00	0.00	0.00
5.00	4.71	1.00	9.60	25.38	0.00	0.00	0.00	0.00	0.00	0.00
6.00	9.83	12.00	9.27	25.37	0.00	0.00	0.00	0.00	0.00	0.00
7.00	4.25	0.00	3.37	25.36	0.00	0.00	0.00	0.00	0.00	0.00
8.00	8.29	13.00	3.27	25.35	0.00	0.00	0.00	0.00	0.00	0.00
9.00	7.08	2.00	9.20	25.35	0.00	0.00	0.00	0.00	0.00	0.00
10.00	7.46	7.00	7.37	25.35	0.00	0.00	0.00	0.00	0.00	0.00
11.00	5.71	3.00	6.88	25.34	0.00	0.00	0.00	0.00	0.00	0.00
12.00	7.63	5.00	7.06	25.34	0.00	0.00	0.00	0.00	0.00	0.00
13.00	4.33	2.00	9999.00	25.33	0.00	0.00	0.00	0.00	0.00	0.00
14.00	3.04	0.00	9999.00	25.32	0.00	0.00	0.00	0.00	0.00	0.00
15.00	4.21	1.00	6.90	25.32	0.00	0.00	0.00	0.00	0.00	0.00
16.00	6.83	3.00	9999.00	25.32	0.00	0.00	0.00	0.00	0.00	0.00
17.00	11.33	21.00	9999.00	25.32	0.00	0.00	0.00	0.00	0.00	0.00
18.00	3.25	0.00	9999.00	25.31	0.00	0.00	0.00	0.00	0.00	0.00
19.00	3.38	0.00	9999.00	25.31	0.00	0.00	0.00	0.00	0.00	0.00
20.00	4.50	1.00	9999.00	25.31	0.00	0.00	0.00	0.00	0.00	0.00
21.00	5.38	1.00	9999.00	25.31	0.00	0.00	0.00	0.00	0.00	0.00
22.00	9.21	10.00	9999.00	25.32	0.00	0.00	0.00	0.00	0.00	0.00
23.00	4.79	1.00	9999.00	25.30	0.00	0.00	0.00	0.00	0.00	0.00
24.00	2.46	0.00	9999.00	25.30	0.00	0.00	0.00	0.00	0.00	0.00
25.00	2.75	0.00	9.23	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
26.00	8.08	7.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
27.00	2.92	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
28.00	5.08	2.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
29.00	3.08	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
30.00	2.63	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
31.00	3.75	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

OCTOBER 1977 (Cont'd)

AVG WSD = 5.69 MPH
AVG WSD 10 MPH OR GREATER FOR 118 HOURS.....PERCENT OF MONTH = 15.86
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 0.00 KWH.....(BASED ON 0.00 A-H)
ENERGY PRODUCED = 0.00 KWH.....(BASED ON 0.00 A-H)
SYSTEM OPERATIONAL FOR 0 HOURS.....PERCENT OF MONTH = 0.00
TURBINE RUNNING DURING 0 HOURS.....PERCENT OF MONTH = 0.00
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

NOVEMBER 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	4.00	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	5.17	4.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	4.88	4.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	5.38	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	5.50	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	4.17	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	14.25	23.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	10.54	19.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	4.71	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	9999.00	1.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
11.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
12.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
13.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
14.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	9999.00	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
16.00	9999.00	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
17.00	4.29	2.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
18.00	5.29	3.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
19.00	7.79	8.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	5.42	1.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
21.00	8.63	10.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
22.00	5.79	5.00	9999.00	26.19	0.00	0.00	0.00	0.00	0.00	0.00
23.00	7.92	13.00	-2.55	27.22	0.00	0.00	0.00	0.00	0.00	0.00
24.00	6.33	3.00	-1.15	28.71	0.00	0.00	0.00	0.00	0.00	0.00
25.00	8.67	12.00	-3.80	28.88	0.00	0.00	0.00	0.00	0.00	0.00
26.00	12.58	14.00	-5.60	28.93	0.00	0.00	0.00	0.00	0.00	0.00
27.00	10.00	14.00	-13.17	28.98	0.00	0.00	0.00	0.00	0.00	0.00
28.00	6.29	8.00	-10.40	27.80	0.00	0.00	0.00	0.00	0.00	0.00
29.00	2.08	0.00	-9.08	26.44	0.00	0.00	0.00	0.00	0.00	0.00
30.00	5.25	3.00	-4.37	26.17	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

NOVEMBER 1977 (Cont'd)

AVG WSD = 6.74 MPH.... BASED ON 23 DAYS
AVG WSD 10 MPH OR GREATER FOR = 147 HOURS (SEE MONTHLY LOG).....PERCENT OF MONTH = 20.42
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 0.00 KWH.....(BASED ON 0.00 A-H)
ENERGY PRODUCED = 0.00 KWH.....(BASED ON 0.00 A-H)
SYSTEM OPERATIONAL FOR 0 HOURS.....PERCENT OF MONTH = 0.00
TURBINE RUNNING DURING 0 HOURS.....PERCENT OF MONTH = 0.00
TOTAL HOURS IN MONTH = 720

UNCLASSIFIED

DECEMBER 1977

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	11.25	21.00	1.08	26.02	0.00	0.00	0.00	0.00	0.00	0.00
2.00	11.50	19.00	1.39	25.97	0.00	0.00	0.00	0.00	0.00	0.00
3.00	7.83	5.00	-0.01	25.94	0.00	0.00	0.00	0.00	0.00	0.00
4.00	3.54	0.00	-5.85	25.91	0.00	0.00	0.00	0.00	0.00	0.00
5.00	8.13	10.00	-9.68	25.88	0.00	0.00	0.00	0.00	0.00	0.00
6.00	10.58	18.00	-6.04	25.85	0.00	0.00	0.00	0.00	0.00	0.00
7.00	9.67	13.00	9999.00	25.84	0.00	0.00	0.00	0.00	0.00	0.00
8.00	3.29	2.00	9999.00	25.81	0.00	0.00	0.00	0.00	0.00	0.00
9.00	13.00	21.00	-8.81	25.80	0.00	0.00	0.00	0.00	0.00	0.00
10.00	11.33	15.00	-17.76	25.78	0.00	0.00	0.00	0.00	0.00	0.00
11.00	5.63	2.00	-24.20	25.74	0.00	0.00	0.00	0.00	0.00	0.00
12.00	7.38	12.00	-20.23	25.71	0.00	0.00	0.00	0.00	0.00	0.00
13.00	12.29	24.00	-14.12	25.70	0.00	0.00	0.00	0.00	0.00	0.00
14.00	9999.00	9.00	-5.17	25.73	0.00	0.00	0.00	0.00	0.00	0.00
15.00	9999.00	0.00	-2.60	25.80	0.00	0.00	0.00	0.00	0.00	0.00
16.00	9999.00	0.00	9999.00	25.82	0.00	0.00	0.00	0.00	0.00	0.00
17.00	2.54	0.00	9999.00	25.79	0.00	0.00	0.00	0.00	0.00	0.00
18.00	10.83	15.00	9999.00	25.77	0.00	0.00	0.00	0.00	0.00	0.00
19.00	11.29	19.00	9999.00	25.76	0.00	0.00	0.00	0.00	0.00	0.00
20.00	11.71	24.00	9999.00	25.77	0.00	0.00	0.00	0.00	0.00	0.00
21.00	9.54	16.00	-2.45	25.76	0.00	0.00	0.00	0.00	0.00	0.00
22.00	6.33	4.00	-2.67	25.83	0.00	0.00	0.00	0.00	0.00	0.00
23.00	6.58	2.00	-0.11	25.80	0.00	0.00	0.00	0.00	0.00	0.00
24.00	5.21	0.00	0.27	25.76	0.00	0.00	0.00	0.00	0.00	0.00
25.00	10.75	14.00	-1.43	25.75	0.00	0.00	0.00	0.00	0.00	0.00
26.00	5.79	3.00	-12.09	25.74	0.00	0.00	0.00	0.00	0.00	0.00
27.00	3.67	0.00	-17.05	25.72	0.00	0.00	0.00	0.00	0.00	0.00
28.00	1.83	0.00	-18.60	25.69	0.00	0.00	0.00	0.00	0.00	0.00
29.00	1.13	0.00	-12.69	25.68	0.00	0.00	0.00	0.00	0.00	0.00
30.00	1.88	0.00	-10.69	25.68	0.00	0.00	0.00	0.00	0.00	0.00
31.00	1.42	0.00	-15.72	25.68	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

DECEMBER 1977 (Cont'd)

AVG WSD = 7.35 *MPH.....BASED ON* 28 *DAYS*
AVG WSD 10 *MPH OR GREATER FOR* 268 *HOURS.....PERCENT OF MONTH =* 36.02
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 0.00 *KWH.....(BASED ON* 0.00 *A-H)*
ENERGY PRODUCED = 0.00 *KWH.....(BASED ON* 0.00 *A-H)*
SYSTEM OPERATIONAL FOR 0 *HOURS.....PERCENT OF MONTH =* 0.00
TURBINE RUNNING DURING 0 *HOURS.....PERCENT OF MONTH =* 0.00
TOTAL HOURS IN MONTH = 744

APPENDIX B

1978 PERFORMANCE DATA SUMMARIES

SUMMARY 1978

MONTH	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	E/OUT (KWH)	E/IN (KWH)	OP (HOURS)	RUN (HOURS)	TOTAL HOURS
1.00	6.90	188.00	9999.00	11.78	13.84	177.00	79.00	744.00
2.00	4.76	95.00	9999.00	29.12	7.64	504.00	72.00	672.00
3.00	6.50	191.00	9999.00	44.96	38.24	744.00	219.00	744.00
4.00	7.64	232.00	9999.00	41.60	42.42	720.00	293.00	720.00
5.00	6.34	195.00	9999.00	39.74	32.46	706.00	240.00	744.00
6.00	6.14	47.00	9999.00	17.75	5.61	324.00	83.00	720.00
7.00	5.00	48.00	9999.00	21.89	3.49	401.00	118.00	744.00
8.00	4.54	62.00	9999.00	26.29	8.78	547.00	160.00	720.00
9.00	5.38	115.00	12.48	28.99	14.25	568.00	180.00	720.00
10.00	6.19	129.00	9999.00	34.65	16.54	699.00	223.00	744.00
11.00	6.84	194.00	0.42	14.00	6.62	270.00	65.00	720.00
12.00	6.97	119.00	9999.00	18.90	2.50	421.00	31.00	744.00

*****9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

AVG WSD = 5.10 *MPH.....(SEE MONTHLY SUMMARY)*
AVG WSD 10 *MPH OR GREATER FOR* 1615 *HOURS.....PERCENT OF YEAR =* 18.49
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY SUMMARY)
ENERGY CONSUMED = 329.67 *KWH*
ENERGY PRODUCED = 192.39 *KWH*
SYSTEM OPERATIONAL FOR 6081 *HOURS.....PERCENT OF YEAR =* 69.61
TURBINE RUNNING DURING 1763 *HOURS.....PERCENT OF YEAR =* 20.18
TOTAL HOURS IN YEAR = 8736

JANUARY 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	6.67	7.00	-15.17	25.68	0.00	0.00	0.00	0.00	0.00	0.00
2.00	5.08	4.00	-13.46	25.67	0.00	0.00	0.00	0.00	0.00	0.00
3.00	6.25	8.00	-14.47	25.70	0.00	0.00	0.00	0.00	0.00	0.00
4.00	3.96	0.00	-16.81	25.68	0.00	0.00	0.00	0.00	0.00	0.00
5.00	2.25	0.00	-10.86	25.67	0.00	0.00	0.00	0.00	0.00	0.00
6.00	3.71	1.00	-15.71	25.67	0.00	0.00	0.00	0.00	0.00	0.00
7.00	8.79	7.00	-13.57	25.67	0.00	0.00	0.00	0.00	0.00	0.00
8.00	7.79	3.00	-3.90	25.66	0.00	0.00	0.00	0.00	0.00	0.00
9.00	17.71	20.00	-13.24	25.66	0.00	0.00	0.00	0.00	0.00	0.00
10.00	18.21	24.00	-19.37	25.66	0.00	0.00	0.00	0.00	0.00	0.00
11.00	5.83	1.00	-13.83	25.64	0.00	0.00	0.00	0.00	0.00	0.00
12.00	3.17	1.00	-19.02	25.59	0.00	0.00	0.00	0.00	0.00	0.00
13.00	4.54	0.00	-14.09	25.62	0.00	0.00	0.00	0.00	0.00	0.00
14.00	10.29	15.00	-14.27	25.64	0.00	0.00	0.00	0.00	0.00	0.00
15.00	6.83	2.00	-16.95	25.64	0.00	0.00	0.00	0.00	0.00	0.00
16.00	3.83	2.00	-19.51	25.63	0.00	0.00	0.00	0.00	0.00	0.00
17.00	2.17	0.00	9999.00	25.61	0.00	0.00	0.00	0.00	0.00	0.00
18.00	7.50	7.00	9999.00	25.56	0.00	0.00	0.00	0.00	0.00	0.00
19.00	1.25	0.00	9999.00	25.51	0.00	0.00	0.00	0.00	0.00	0.00
20.00	6.50	2.00	9999.00	25.77	0.00	0.00	0.00	0.00	0.00	0.00
21.00	5.29	0.00	9999.00	25.61	0.00	0.00	0.00	0.00	0.00	0.00
22.00	3.13	0.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
23.00	6.92	3.00	9999.00	26.63	0.00	0.00	0.00	0.00	0.00	0.00
24.00	4.63	1.00	-3.24	25.61	21.75	0.56	0.00	0.00	9.00	0.00
25.00	4.83	4.00	9999.00	25.53	58.83	1.50	37.70	0.96	24.00	4.00
26.00	16.58	24.00	9999.00	28.16	64.76	1.82	214.60	6.04	24.00	24.00
27.00	12.71	20.00	-8.67	27.95	64.29	1.80	140.30	3.92	24.00	21.00
28.00	9.29	14.00	-14.28	26.53	61.16	1.62	50.30	1.33	24.00	14.00
29.00	9.08	12.00	-15.39	25.67	59.07	1.52	32.00	0.82	24.00	8.00
30.00	7.88	6.00	-16.03	25.59	59.09	1.51	30.20	0.77	24.00	8.00
31.00	1.33	0.00	-17.31	25.04	57.86	1.45	0.00	0.00	24.00	0.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

JANUARY 1978 (Cont'd)

AVG WSD = 6.90 *MPH*
AVG WSD 10 *MPH OR GREATER FOR* 188 *HOURS.....PERCENT OF MONTH =* 25.27
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 11.78 *KWH.....(BASED ON* 446.81 *A-H)*
ENERGY PRODUCED = 13.84 *KWH.....(BASED ON* 505.10 *A-H)*
SYSTEM OPERATIONAL FOR 177 *HOURS.....PERCENT OF MONTH =* 23.79
TURBINE RUNNING DURING 79 *HOURS.....PERCENT OF MONTH =* 10.62
TOTAL HOURS IN MONTH = 744

FEBRUARY 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	4.71	5.00	-14.62	25.12	58.05	1.46	15.70	0.39	24.00	7.00
2.00	2.42	0.00	-15.91	24.88	57.51	1.43	0.00	0.00	24.00	0.00
3.00	1.54	0.00	-21.60	24.76	57.25	1.42	0.00	0.00	24.00	0.00
4.00	2.17	0.00	-23.29	24.64	56.95	1.40	0.00	0.00	24.00	0.00
5.00	2.08	0.00	-20.52	24.49	56.64	1.39	0.00	0.00	24.00	0.00
6.00	6.33	7.00	-11.22	24.69	57.11	1.41	21.80	0.54	24.00	8.00
7.00	12.04	22.00	-5.64	26.16	60.37	1.58	151.90	3.97	24.00	24.00
8.00	3.88	0.00	-10.57	25.03	57.82	1.45	0.10	0.00	24.00	1.00
9.00	6.33	5.00	9999.00	24.63	56.88	1.40	10.10	0.25	24.00	4.00
10.00	3.13	0.00	9999.00	24.32	56.19	1.37	0.20	0.00	24.00	1.00
11.00	3.95	2.00	-13.11	24.27	56.13	1.36	8.40	0.20	24.00	4.00
12.00	8.92	11.00	-7.52	24.95	57.64	1.44	63.80	1.59	24.00	13.00
13.00	5.29	1.00	-13.56	24.16	55.90	1.35	0.00	0.00	24.00	0.00
14.00	2.67	0.00	-16.68	23.94	55.38	1.33	0.00	0.00	24.00	0.00
15.00	1.25	0.00	-15.54	23.76	54.99	1.31	0.00	0.00	24.00	0.00
16.00	3.46	0.00	-10.51	23.58	54.58	1.29	0.00	0.00	24.00	0.00
17.00	4.79	0.00	-6.05	23.42	54.19	1.27	0.10	0.00	24.00	1.00
18.00	3.83	1.00	-10.50	23.22	53.76	1.25	0.00	0.00	24.00	0.00
19.00	4.38	0.00	-14.78	23.04	53.44	1.23	2.00	0.05	24.00	3.00
20.00	1.38	0.00	-13.56	24.36	24.27	0.59	0.00	0.00	11.00	0.00
21.00	6.50	6.00	-13.04	26.35	0.00	0.00	0.00	0.00	0.00	0.00
22.00	10.50	16.00	-8.96	28.03	0.00	0.00	0.00	0.00	0.00	0.00
23.00	6.21	5.00	-6.47	28.67	0.00	0.00	0.00	0.00	0.00	0.00
24.00	4.55	0.00	9999.00	28.76	0.00	0.00	0.00	0.00	0.00	0.00
25.00	3.71	0.00	-10.49	28.93	0.00	0.00	0.00	0.00	0.00	0.00
26.00	8.00	7.00	-10.18	28.95	0.00	0.00	0.00	0.00	0.00	0.00
27.00	7.54	7.00	-11.47	27.88	33.66	0.94	23.30	0.65	13.00	6.00
28.00	1.67	0.00	-12.95	24.56	58.86	1.45	0.00	0.00	24.00	0.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

FEBRUARY 1978 (Cont'd)

AVG WSD = 4.76 *MPH*
AVG WSD 10 *MPH OR GREATER FOR* 95 *HOURS.....PERCENT OF MONTH =* 14.14
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 29.12 *KWH.....(BASED ON* 1187.57 *A-H)*
ENERGY PRODUCED = 7.64 *KWH.....(BASED ON* 297.40 *A-H)*
SYSTEM OPERATIONAL FOR 504 *HOURS.....PERCENT OF MONTH =* 75.00
TURBINE RUNNING DURING 72 *HOURS.....PERCENT OF MONTH =* 10.71
TOTAL HOURS IN MONTH = 672

MARCH 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	3.08	1.00	-12.07	25.36	58.56	1.49	2.90	0.07	24.00	2.00
2.00	3.67	2.00	-13.06	25.27	58.36	1.47	6.60	0.17	24.00	3.00
3.00	3.88	0.00	9999.00	25.11	58.02	1.46	0.00	0.00	24.00	0.00
4.00	9.88	16.00	-12.29	25.97	59.96	1.56	120.20	3.12	24.00	15.00
5.00	7.50	8.00	-13.81	25.96	59.90	1.56	67.00	1.74	24.00	10.00
6.00	9.83	11.00	9999.00	26.18	60.41	1.58	102.00	2.67	24.00	13.00
7.00	10.17	15.00	9999.00	9999.00	60.52	1.45	159.80	3.84	24.00	18.00
8.00	1.71	0.00	9999.00	9999.00	58.25	1.40	0.00	0.00	24.00	0.00
9.00	5.38	3.00	9999.00	9999.00	57.99	1.39	34.60	0.83	24.00	9.00
10.00	2.17	0.00	9999.00	24.98	57.63	1.44	0.00	0.00	24.00	0.00
11.00	4.83	3.00	-0.71	24.97	57.65	1.44	8.50	0.21	24.00	4.00
12.00	3.92	1.00	-0.32	24.84	57.37	1.43	2.10	0.05	24.00	3.00
13.00	2.92	0.00	-2.95	24.71	57.08	1.41	0.00	0.00	24.00	0.00
14.00	7.50	7.00	0.60	24.82	57.30	1.42	48.10	1.19	24.00	6.00
15.00	11.58	19.00	-2.72	25.68	59.26	1.52	135.20	3.47	24.00	22.00
16.00	3.88	0.00	9999.00	24.94	57.49	1.43	0.80	0.02	24.00	2.00
17.00	2.75	0.00	9999.00	24.51	56.77	1.39	3.50	0.09	24.00	2.00
18.00	6.25	6.00	9999.00	9999.00	56.80	1.36	14.80	0.36	24.00	10.00
19.00	16.88	24.00	9999.00	9999.00	63.91	1.53	328.10	7.87	24.00	20.00
20.00	5.46	3.00	9999.00	24.93	61.11	1.52	0.00	0.00	24.00	0.00
21.00	5.00	5.00	9999.00	9999.00	61.09	1.47	2.70	0.06	24.00	3.00
22.00	7.08	6.00	9999.00	24.34	56.81	1.38	1.20	0.03	24.00	1.00
23.00	4.46	3.00	9999.00	24.39	56.38	1.37	16.50	0.40	24.00	4.00
24.00	12.96	17.00	-8.61	25.94	59.88	1.55	246.40	6.39	24.00	18.00
25.00	1.42	0.00	-7.05	24.88	57.47	1.43	0.00	0.00	24.00	0.00
26.00	9.33	16.00	-4.41	25.20	58.17	1.47	66.10	1.67	24.00	17.00
27.00	8.17	7.00	-0.25	24.75	57.18	1.42	11.90	0.29	24.00	6.00
28.00	7.50	2.00	2.60	24.39	56.34	1.37	4.00	0.10	24.00	7.00
29.00	11.67	15.00	0.38	25.20	58.18	1.47	136.20	3.43	24.00	18.00
30.00	5.67	0.00	-0.65	24.66	56.98	1.41	1.60	0.04	24.00	3.00
31.00	5.08	1.00	9999.00	24.30	56.18	1.37	5.30	0.13	24.00	3.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

MARCH 1978 (Cont'd)

AVG WSD = 6.50 MPH
AVG WSD 10 MPH OR GREATER FOR 191 HOURS.....PERCENT OF MONTH = 25.67
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 44.96 KWH.....(BASED ON 1809.00 A-H)
ENERGY PRODUCED = 38.24 KWH.....(BASED ON 1526.10 A-H)
SYSTEM OPERATIONAL FOR 744 HOURS.....PERCENT OF MONTH = 100.00
TURBINE RUNNING DURING 219 HOURS.....PERCENT OF MONTH = 29.44
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

APRIL 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	14.08	19.00	9999.00	25.14	58.01	1.46	156.10	3.92	24.00	17.00
2.00	14.42	19.00	-4.32	25.71	59.36	1.53	163.20	4.20	24.00	17.00
3.00	5.79	0.00	-4.20	24.91	57.53	1.43	5.90	0.15	24.00	7.00
4.00	4.38	0.00	-1.23	24.51	56.64	1.39	0.10	0.00	24.00	1.00
5.00	9.88	13.00	1.12	25.11	57.99	1.46	79.80	2.00	24.00	17.00
6.00	3.08	0.00	-0.83	24.34	56.26	1.37	0.00	0.00	24.00	0.00
7.00	6.13	2.00	0.90	24.21	55.97	1.36	4.50	0.11	24.00	5.00
8.00	14.92	22.00	-2.19	25.80	59.59	1.54	223.90	5.78	24.00	23.00
9.00	8.29	10.00	-4.71	25.19	58.17	1.47	33.60	0.85	24.00	15.00
10.00	2.71	0.00	9999.00	24.62	56.88	1.40	0.00	0.00	24.00	0.00
11.00	8.67	10.00	9999.00	24.98	57.60	1.44	55.00	1.37	24.00	14.00
12.00	5.67	4.00	3.52	24.46	56.49	1.38	19.50	0.48	24.00	6.00
13.00	6.63	7.00	9999.00	24.54	56.71	1.37	40.40	0.99	24.00	12.00
14.00	12.13	16.00	2.34	25.44	58.72	1.49	158.90	4.04	24.00	20.00
15.00	8.13	8.00	1.69	24.94	57.60	1.44	38.00	0.95	24.00	9.00
16.00	5.54	0.00	3.89	24.44	56.46	1.38	1.30	0.03	24.00	1.00
17.00	2.58	0.00	4.55	24.18	55.87	1.35	0.00	0.00	24.00	0.00
18.00	4.17	0.00	5.30	24.03	55.54	1.33	0.00	0.00	24.00	0.00
19.00	8.54	12.00	9999.00	24.42	56.43	1.38	57.70	1.41	24.00	14.00
20.00	7.79	6.00	2.92	24.40	56.38	1.38	32.80	0.80	24.00	12.00
21.00	8.21	11.00	4.02	24.36	56.29	1.37	43.60	1.06	24.00	12.00
22.00	7.63	8.00	4.15	23.95	55.37	1.33	21.20	0.51	24.00	12.00
23.00	6.75	8.00	4.92	24.04	55.56	1.34	35.20	0.85	24.00	9.00
24.00	6.96	6.00	7.40	23.94	55.34	1.32	29.80	0.71	24.00	9.00
25.00	5.96	6.00	8.57	23.67	54.74	1.30	19.30	0.46	24.00	9.00
26.00	3.08	0.00	8.38	23.37	54.07	1.26	0.00	0.00	24.00	0.00
27.00	4.21	2.00	8.92	23.24	53.76	1.25	8.80	0.20	24.00	5.00
28.00	6.71	5.00	9999.00	23.55	54.53	1.28	39.50	0.93	24.00	9.00
29.00	10.42	14.00	6.18	24.02	55.56	1.33	159.00	3.82	24.00	14.00
30.00	15.83	24.00	-0.44	25.27	58.36	1.47	268.90	6.80	24.00	24.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

APRIL 1978 (Cont'd)

AVG WSD = 7.64 MPH
AVG WSD 10 MPH OR GREATER FOR 232 HOURS.....PERCENT OF MONTH = 32.22
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 41.60 KWH.....(BASED ON 1697.78 A-H)
ENERGY PRODUCED = 42.42 KWH.....(BASED ON 1696.00 A-H)
SYSTEM OPERATIONAL FOR 720 HOURS.....PERCENT OF MONTH = 100.00
TURBINE RUNNING DURING 293 HOURS.....PERCENT OF MONTH = 40.69
TOTAL HOURS IN MONTH = 720

UNCLASSIFIED

	[illegible]	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
	5.17	24.00	0.65	25.86	59.66	1.54	243.70	6.30	24.00	24.00
	0.96	19.00	4.72	25.64	59.15	1.52	97.50	2.50	24.00	20.00
	7.71	9.00	3.47	25.00	57.74	1.44	30.70	0.77	24.00	11.00
	4.67	0.00	7.32	24.59	56.79	1.40	0.00	0.00	24.00	0.00
	7.79	8.00	10.18	24.58	56.75	1.39	30.10	0.74	24.00	12.00
5.00	3.29	0.00	11.77	24.22	55.95	1.36	0.00	0.00	24.00	0.00
7.00	2.75	0.00	14.15	24.04	55.53	1.33	0.00	0.00	24.00	0.00
8.00	8.75	13.00	13.91	24.37	56.26	1.37	69.90	1.70	24.00	14.00
9.00	8.04	6.00	13.17	24.19	55.84	1.35	31.20	0.75	24.00	12.00
10.00	8.42	10.00	9.14	24.46	56.53	1.38	80.60	1.97	24.00	12.00
11.00	5.13	5.00	13.67	23.99	55.36	1.33	10.90	0.26	24.00	7.00
12.00	3.58	0.00	13.20	23.69	54.76	1.30	0.00	0.00	24.00	0.00
13.00	8.38	8.00	15.55	23.99	55.42	1.33	56.00	1.34	24.00	13.00
14.00	10.54	11.00	16.39	24.51	56.59	1.39	146.40	3.59	24.00	16.00
15.00	12.63	18.00	11.99	25.02	57.72	1.44	168.80	4.22	24.00	20.00
16.00	10.29	15.00	17.00	24.97	57.64	1.44	80.60	2.01	24.00	17.00
17.00	7.17	9.00	13.17	24.70	57.03	1.41	46.70	1.15	24.00	11.00
18.00	2.21	0.00	15.85	24.18	55.84	1.35	0.00	0.00	24.00	0.00
19.00	5.54	5.00	19.62	24.04	55.52	1.33	16.40	0.39	24.00	7.00
20.00	7.04	7.00	19.34	24.09	55.61	1.34	37.90	0.91	24.00	9.00
21.00	11.63	17.00	13.63	24.73	57.07	1.41	135.30	3.35	24.00	19.00
22.00	6.54	9.00	15.17	24.24	55.98	1.36	18.40	0.45	24.00	10.00
23.00	3.42	1.00	19.68	23.86	55.14	1.32	0.20	0.00	24.00	2.00
24.00	2.79	0.00	21.48	23.63	54.63	1.29	0.00	0.00	24.00	0.00
25.00	3.25	0.00	22.41	23.44	54.29	1.27	0.00	0.00	24.00	0.00
26.00	2.88	0.00	24.58	23.24	53.77	1.25	0.00	0.00	24.00	0.00
27.00	4.50	0.00	26.10	23.05	53.33	1.23	0.30	0.01	24.00	2.00
28.00	4.42	1.00	26.38	22.88	52.95	1.21	2.40	0.05	24.00	2.00
29.00	2.54	0.00	25.45	21.84	52.51	1.15	0.00	0.00	24.00	0.00
30.00	1.75	0.00	24.28	23.59	21.75	0.51	0.00	0.00	10.00	0.00
31.00	2.67	0.00	9999.00	25.16	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

MAY 1978 (Cont'd)

AVG WSD = 6.34 MPH
AVG WSD 10 MPH OR GREATER FOR 195 HOURS.....PERCENT OF MONTH = 26.21
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 39.74 KWH.....(BASED ON 1643.11 A-H)
ENERGY PRODUCED = 32.46 KWH.....(BASED ON 1304.00 A-H)
SYSTEM OPERATIONAL FOR 706 HOURS.....PERCENT OF MONTH = 94.89
TURBINE RUNNING DURING 240 HOURS.....PERCENT OF MONTH = 32.26
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

JUNE 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	4.59	0.00	9999.00	25.06	33.58	0.84	0.00	0.00	14.00	0.00
2.00	5.88	4.00	19.19	24.71	57.04	1.41	18.50	0.46	24.00	9.00
3.00	6.71	0.00	14.57	24.37	56.32	1.37	1.50	0.04	24.00	6.00
4.00	5.29	0.00	14.70	24.13	55.77	1.35	0.00	0.00	24.00	0.00
5.00	6.79	7.00	10.65	24.44	56.30	1.38	55.80	1.36	24.00	8.00
6.00	6.33	3.00	15.78	24.01	55.49	1.33	10.90	0.26	24.00	11.00
7.00	4.29	0.00	18.43	23.78	54.97	1.31	0.00	0.00	24.00	0.00
8.00	6.00	6.00	16.73	23.77	54.97	1.31	14.00	0.33	24.00	7.00
9.00	7.63	6.00	13.54	23.82	55.10	1.31	36.70	0.87	24.00	11.00
10.00	5.00	1.00	13.75	23.37	54.07	1.26	2.20	0.05	24.00	2.00
11.00	7.83	11.00	20.99	23.85	55.13	1.31	57.70	1.38	24.00	11.00
12.00	9.43	7.00	9999.00	23.65	31.90	0.75	26.70	0.63	14.00	7.00
13.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
14.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
15.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
16.00	4.94	0.00	9999.00	23.07	35.55	0.82	1.70	0.04	16.00	2.00
17.00	6.25	2.00	20.83	22.86	52.91	1.21	4.60	0.11	24.00	6.00
18.00	5.19	0.00	9999.00	22.68	35.00	0.79	3.50	0.08	16.00	3.00
19.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
20.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
21.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
22.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
23.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
24.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
26.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
27.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
28.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
29.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
30.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

JUNE 1978 (Cont'd)

AVG WSD = 6.14 MPH.....BASED ON 15 DAYS
AVG WSD 10 MPH OR GREATER FOR = 47 HOURS (SEE MONTHLY LOG).....PERCENT OF MONTH = 6.53
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 17.75 KWH.....(BASED ON 744.10 A-H)
ENERGY PRODUCED = 5.61 KWH.....(BASED ON 233.80 A-H)
SYSTEM OPERATIONAL FOR 324 HOURS.....PERCENT OF MONTH = 45.00
TURBINE RUNNING DURING 83 HOURS.....PERCENT OF MONTH = 11.53
TOTAL HOURS IN MONTH = 720

JULY 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
3.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
6.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
7.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
8.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
9.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
10.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
11.00	6.77	5.00	9999.00	23.60	27.68	0.65	12.70	0.30	12.00	6.00
12.00	5.67	3.00	20.82	23.42	55.42	1.30	10.20	0.24	24.00	10.00
13.00	5.10	4.00	9999.00	23.24	47.77	1.11	11.30	0.26	21.00	5.00
14.00	3.25	0.00	21.90	22.87	54.14	1.24	0.00	0.00	24.00	0.00
15.00	4.38	0.00	24.06	22.53	53.34	1.20	1.00	0.02	24.00	5.00
16.00	5.00	2.00	20.67	22.18	52.53	1.16	5.10	0.11	24.00	9.00
17.00	4.00	0.00	20.96	23.53	16.81	0.40	0.00	0.00	8.00	0.00
18.00	3.50	0.00	22.82	25.01	0.00	0.00	0.00	0.00	0.00	0.00
19.00	2.92	0.00	22.58	25.64	0.00	0.00	0.00	0.00	0.00	0.00
20.00	6.46	7.00	26.69	25.65	25.69	0.66	17.40	0.45	11.00	6.00
21.00	1.83	0.00	24.02	24.71	58.38	1.44	0.00	0.00	24.00	0.00
22.00	2.67	0.00	22.50	24.42	57.35	1.40	0.00	0.00	24.00	0.00
23.00	9.25	11.00	22.42	24.46	57.75	1.41	44.50	1.09	24.00	17.00
24.00	4.04	0.00	20.72	24.13	56.93	1.37	0.00	0.00	24.00	0.00
25.00	5.08	0.00	24.39	23.95	56.30	1.35	3.50	0.08	24.00	8.00
26.00	6.75	6.00	24.26	23.81	56.25	1.34	12.70	0.30	24.00	10.00
27.00	6.57	2.00	9999.00	23.70	56.08	1.33	12.70	0.30	24.00	11.00
28.00	7.13	6.00	19.00	23.52	55.68	1.31	12.50	0.29	24.00	14.00
29.00	3.63	0.00	14.22	23.25	55.00	1.28	0.00	0.00	24.00	0.00
30.00	5.88	1.00	15.17	22.97	54.32	1.25	1.90	0.04	24.00	13.00
31.00	5.17	0.00	16.15	23.61	29.16	0.69	0.60	0.01	13.00	4.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED
UNCLASSIFIED

JULY 1978 (Cont'd)

AVG WSD = 5.00 MPH.....BASED ON 21 DAYS
AVG WSD 10 MPH OR GREATER FOR = 48 HOURS (SEE MONTHLY LOG).....PERCENT OF MONTH = 6.45
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 21.89 KWH.....(BASED ON 926.58 A-H)
ENERGY PRODUCED = 3.49 KWH.....(BASED ON 146.10 A-H)
SYSTEM OPERATIONAL FOR 401 HOURS.....PERCENT OF MONTH = 53.90
TURBINE RUNNING DURING 118 HOURS.....PERCENT OF MONTH = 15.86
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

AUGUST 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	3.92	0.00	21.90	24.44	28 [illegible]9	0.69	0.00	0.00	12.00	0.00
2.00	5.00	2.00	23.22	23.66	55.95	1.32	8.70	0.21	24.00	6.00
3.00	4.00	0.00	20.70	23.30	55.14	1.28	2.80	0.07	24.00	4.00
4.00	6.71	3.00	18.72	23.07	54.64	1.26	17.00	0.39	24.00	13.00
5.00	5.13	2.00	20.12	22.76	53.85	1.23	8.20	0.19	24.00	8.00
6.00	3.33	0.00	21.36	22.36	52.96	1.18	0.00	0.00	24.00	0.00
7.00	3.25	0.00	22.46	21.87	51.85	1.13	2.70	0.06	24.00	4.00
8.00	0.79	0.00	22.68	20.70	45.95	0.95	0.00	0.00	23.00	0.00
9.00	4.71	4.00	22.57	21.31	50.06	1.07	26.30	0.56	24.00	10.00
10.00	2.88	0.00	18.85	21.79	19.48	0.42	0.00	0.00	10.00	0.00
11.00	2.58	0.00	19.31	23.32	0.00	0.00	0.00	0.00	0.00	0.00
12.00	2.79	0.00	22.14	24.00	0.00	0.00	0.00	0.00	0.00	0.00
13.00	3.54	0.00	23.70	24.52	0.00	0.00	0.00	0.00	0.00	0.00
14.00	2.75	0.00	25.96	24.82	0.00	0.00	0.00	0.00	0.00	0.00
15.00	3.88	0.00	26.56	25.12	0.00	0.00	0.00	0.00	0.00	0.00
16.00	5.96	5.00	23.66	24.67	1.40	0.03	23.90	0.59	14.00	12.00
17.00	9.77	13.00	9999.00	24.47	35.71	0.87	100.80	2.47	24.00	24.00
18.00	3.75	0.00	21.30	23.18	54.85	1.27	0.00	0.00	24.00	0.00
19.00	4.29	0.00	20.08	22.88	54.12	1.24	2.00	0.05	24.00	4.00
20.00	7.38	8.00	19.01	23.13	54.76	1.27	42.50	0.98	24.00	17.00
21.00	2.58	0.00	17.51	22.65	53.56	1.21	0.00	0.00	24.00	0.00
22.00	4.08	0.00	20.44	22.51	53.25	1.20	0.00	0.00	24.00	0.00
23.00	5.67	0.00	17.35	22.49	53.17	1.20	9.50	0.21	24.00	6.00
24.00	7.63	9.00	12.37	22.87	54.17	1.24	55.20	1.26	24.00	14.00
25.00	4.63	0.00	15.17	22.26	52.70	1.17	1.30	0.03	24.00	3.00
26.00	5.50	7.00	16.67	22.40	52.99	1.19	24.30	0.54	24.00	9.00
27.00	3.25	0.00	14.97	22.01	52.13	1.15	0.00	0.00	24.00	0.00
28.00	6.75	1.00	15.30	22.09	52.32	1.16	19.70	0.44	24.00	9.00
29.00	7.42	6.00	19.20	22.10	52.43	1.16	32.90	0.73	24.00	17.00
30.00	4.00	2.00	17.46	23.12	17.16	0.40	0.00	0.00	8.00	0.00
31.00	2.88	0.00	16.07	24.63	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

AUGUST 1978 (Cont'd)

AVG WSD = 4.54 MPH
AVG WSD 10 MPH OR GREATER FOR 62 HOURS.....PERCENT OF MONTH = 8.33
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 26.29 KWH.....(BASED ON 1162.89 A-H)
ENERGY PRODUCED = 8.78 KWH.....(BASED ON 377.80 A-H)
SYSTEM OPERATIONAL FOR 547 HOURS.....PERCENT OF MONTH = 73.52
TURBINE RUNNING DURING 160 HOURS.....PERCENT OF MONTH = 21.51
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

SEPTEMBER 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	3.21	0.00	15.50	24.39	29.50	0.72	0.00	0.00	13.00	0.00
2.00	6.50	7.00	19.06	23.49	55.60	1.31	40.70	0.96	24.00	9.00
3.00	6.00	3.00	16.53	22.98	54.39	1.25	17.10	0.39	24.00	7.00
4.00	6.04	1.00	15.52	22.74	53.78	1.22	10.80	0.25	24.00	8.00
5.00	4.50	0.00	15.46	22.50	53.23	1.20	0.00	0.00	24.00	0.00
6.00	7.08	11.00	19.17	22.88	54.08	1.24	53.40	1.22	24.00	13.00
7.00	8.17	12.00	14.05	23.22	55.02	1.28	77.60	1.80	24.00	14.00
8.00	2.79	0.00	12.62	22.37	52.94	1.18	0.00	0.00	24.00	0.00
9.00	7.54	11.00	9.99	22.88	54.21	1.24	62.40	1.43	24.00	13.00
10.00	3.04	0.00	9.81	22.15	52.49	1.16	0.00	0.00	24.00	0.00
11.00	3.54	0.00	14.30	21.98	52.03	1.14	0.00	0.00	24.00	0.00
12.00	8.46	11.00	11.94	22.68	53.84	1.22	74.70	1.69	24.00	17.00
13.00	3.83	0.00	10.44	21.93	51.95	1.14	0.90	0.02	24.00	2.00
14.00	6.50	1.00	11.49	21.86	51.75	1.13	12.50	0.27	24.00	9.00
15.00	9.75	15.00	17.33	22.72	53.83	1.22	91.30	2.07	24.00	22.00
16.00	6.58	7.00	12.05	22.25	52.64	1 17	29.30	0.65	24.00	12.00
17.00	2.21	0.00	8.48	21.67	51.37	1.11	0.00	0.00	24.00	0.00
18.00	4.04	0.00	7.45	21.54	51.07	1.10	3.50	0.08	24.00	3.00
19.00	3.63	0.00	12.27	22.52	25.40	0.57	0.00	0.00	12.00	0.00
20.00	2.13	0.00	13.06	24.32	0.00	0.00	0.00	0.00	0.00	0.00
21.00	4.21	0.00	14.86	25.21	0.00	0.00	0.00	0.00	0.00	0.00
22.00	4.83	1.00	10.02	25.96	0.00	0.00	0.00	0.00	0.00	0.00
23.00	3.13	0.00	9.56	26.22	0.00	0.00	0.00	0.00	0.00	0.00
24.00	5.54	6.00	13.09	26.19	0.00	0.00	0.00	0.00	0.00	0.00
25.00	8.67	12.00	8.04	25.38	35.51	0.90	60.20	1.53	15.00	10.00
26.00	4.83	0.00	8.84	24.05	56.60	1.36	5.00	0.12	24.00	5.00
27.00	7.08	3.00	14.72	23.51	55.56	1.31	8.40	0.20	24.00	10.00
28.00	7.96	10.00	7.77	23.62	55.76	1.32	46.00	1.09	24.00	14.00
29.00	3.25	0.00	8.26	22.97	54.30	1.25	1.50	0.03	24.00	2.00
30.00	6.38	4.00	12.85	22.99	54.30	1.25	19.60	0.45	24.00	10.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

SEPTEMBER 1978 (Cont'd)

AVG WSD = 5.38 MPH
AVG WSD 10 MPH OR GREATER FOR 115 HOURS.....PERCENT OF MONTH = 15.97
AVG TEMP = 12.48 C
ENERGY CONSUMED = 28.99 KWH.....(BASED ON 1271.15 A-H)
ENERGY PRODUCED = 14.25 KWH.....(BASED ON 614.90 A-H)
SYSTEM OPERATIONAL FOR 568 HOURS.....PERCENT OF MONTH = 78.89
TURBINE RUNNING DURING 180 HOURS.....PERCENT OF MONTH = 25.00
TOTAL HOURS IN MONTH = 720

UNCLASSIFIED

OCTOBER 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	9.42	10.00	13.49	23.44	55.44	1.30	61.40	1.44	24.00	17.00
2.00	4.67	0.00	9.13	22.76	53.86	1.23	0.00	0.00	24.00	0.00
3.00	8.42	11.00	8.39	23.41	55.18	1.29	72.80	1.70	24.00	19.00
4.00	7.17	6.00	9999.00	23.12	54.73	1.27	32.60	0.75	24.00	10.00
5.00	3.75	0.00	11.99	22.57	53.39	1.21	0.00	0.00	24.00	0.00
6.00	6.83	4.00	13.12	22.64	53.60	1.21	20.70	0.47	24.00	7.00
7.00	9.63	13.00	5.41	23.22	54.76	1.27	80.50	1.87	24.00	19.00
8.00	8.54	9.00	2.26	23.10	54.61	1.26	51.00	1.18	24.00	16.00
9.00	7.21	5.00	5.26	22.76	53.87	1.23	29.70	0.68	24.00	8.00
10.00	6.54	7.00	11.66	22.71	53.79	1.22	34.60	0.79	24.00	11.00
11.00	5.00	1.00	13.42	22.30	52.73	1.18	3.30	0.07	24.00	4.00
12.00	8.46	9.00	13.85	22.85	54.06	1.24	68.40	1.56	24.00	11.00
13.00	4.88	0.00	9.11	22.22	52.58	1.17	0.00	0.00	24.00	0.00
14.00	7.21	3.00	2.40	22.06	52.18	1.15	9.80	0.22	24.00	9.00
15.00	6.38	3.00	0.32	21.87	51.80	1.13	4.60	0.10	24.00	9.00
16.00	3.50	0.00	-0.83	21.66	50.07	1.08	0.00	0.00	24.00	0.00
17.00	3.42	0.00	0.47	21.48	50.92	1.09	0.00	0.00	24.00	0.00
18.00	5.50	2.00	4.38	21.47	50.90	1.09	12.10	0.26	24.00	4.00
19.00	4.00	1.00	4.90	22.57	21.14	0.48	6.40	0.14	10.00	3.00
20.00	4.42	0.00	4.82	24.22	0.00	0.00	0.00	0.00	0.00	0.00
21.00	5.63	1.00	11.55	23.71	36.75	0.87	4.20	0.10	17.00	3.00
22.00	6.75	4.00	16.45	22.90	54.27	1.24	24.80	0.57	24.00	9.00
23.00	10.00	17.00	4.82	23.36	55.33	1.29	97.20	2.27	24.00	20.00
24.00	4.08	0.00	-0.16	22.51	53.27	1.20	1.50	0.03	24.00	4.00
25.00	7.50	10.00	6.77	22.64	53.47	1.21	37.00	0.84	24.00	10.00
26.00	5.46	0.00	8.92	22.16	52.51	1.16	5.20	0.12	24.00	4.00
27.00	5.71	1.00	4.74	21.97	52.05	1.14	5.90	0.13	24.00	5.00
28.00	7.04	6.00	5.23	22.14	52.49	1.16	35.70	0.79	24.00	12.00
29.00	3.63	0.00	0.38	21.60	51.23	1.11	0.00	0.00	24.00	0.00
30.00	5.17	4.00	2.90	21.43	50.82	1.09	7.80	0.17	24.00	3.00
31.00	5.88	2.00	8.40	21.38	50.62	1.08	13.40	0.29	24.00	6.00

***** 9999.00 INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

OCTOBER 1978 (Cont'd)

AVG WSD = 6.19 MPH
AVG WSD 10 MPH OR GREATER FOR 129 HOURS.....PERCENT OF MONTH = 17.34
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 34.65 KWH.....(BASED ON 1542.42 A-H)
ENERGY PRODUCED = 16.54 KWH.....(BASED ON 720.60 A-H)
SYSTEM OPERATIONAL FOR 699 HOURS.....PERCENT OF MONTH = 93.95
TURBINE RUNNING DURING 223 HOURS.....PERCENT OF MONTH = 29.97
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

NOVEMBER 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	3.67	0.00	3.67	22.14	26.98	0.60	0.00	0.00	13.00	0.00
2.00	7.21	9.00	6.26	24.38	0.00	0.00	0.00	0.00	0.00	0.00
3.00	2.58	0.00	5.72	24.10	31.73	0.76	0.00	0.00	14.00	0.00
4.00	3.25	0.00	8.22	22.82	53.97	1.23	0.00	0.00	24.00	0.00
5.00	5.58	2.00	9.32	22.52	53.31	1.20	14.70	0.33	24.00	6.00
6.00	5.96	3.00	10.41	22.24	52.61	1.17	9.00	0.20	24.00	9.00
7.00	4.54	0.00	2.05	21.94	51.96	1.14	0.00	0.00	24.00	0.00
8.00	5.00	1.00	0.49	21.71	51.40	1.12	3.90	0.08	24.00	5.00
9.00	5.67	1.00	8.35	21.48	50.91	1.09	3.90	0.08	24.00	6.00
10.00	7.75	5.00	6.16	22.51	28.33	0.64	19.20	0.43	14.00	5.00
11.00	7.33	6.00	3.77	24.51	0.00	0.00	0.00	0.00	0.00	0.00
12.00	5.25	5.00	-2.91	25.70	0.00	0.00	0.00	0.00	0.00	0.00
13.00	6.54	1.00	-2.05	26.12	0.00	0.00	0.00	0.00	0.00	0.00
14.00	12.54	21.00	8.39	26.50	0.00	0.00	0.00	0.00	0.00	0.00
15.00	7.08	8.00	-2.27	26.55	0.00	0.00	0.00	0.00	0.00	0.00
16.00	2.54	0.00	-0.56	26.57	0.00	0.00	0.00	0.00	0.00	0.00
17.00	7.46	11.00	-0.20	26.51	0.00	0.00	0.00	0.00	0.00	0.00
18.00	12.38	16.00	5.60	25.95	0.00	0.00	0.00	0.00	0.00	0.00
19.00	10.17	11.00	0.70	25.40	0.00	0.00	0.00	0.00	0.00	0.00
20.00	6.38	5.00	-10.21	26.41	0.00	0.00	0.00	0.00	0.00	0.00
21.00	2.13	0.00	-11.98	27.68	0.00	0.00	0.00	0.00	0.00	0.00
22.00	2.67	0.00	-9.67	27.62	0.00	0.00	0.00	0.00	0.00	0.00
23.00	9.88	14.00	-4.06	27.43	0.00	0.00	0.00	0.00	0.00	0.00
24.00	9.04	14.00	-0.54	27.21	0.00	0.00	0.00	0.00	0.00	0.00
25.00	11.42	20.00	-7.20	27.34	0.00	0.00	0.00	0.00	0.00	0.00
26.00	7.33	7.00	-13.90	27.63	0.00	0.00	0.00	0.00	0.00	0.00
27.00	11.08	14.00	-12.85	27.33	33.95	0.93	115.30	3.15	13.00	13.00
28.00	6.46	5.00	-9.55	24.45	57.74	1.41	11.20	0.27	24.00	6.00
29.00	6.17	4.00	-5.85	23.55	55.66	1.31	4.30	0.10	24.00	4.00
30.00	10.13	11.00	-2.39	24.37	57.31	1.40	81.10	1.98	24.00	11.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

NOVEMBER 1978 (Cont'd)

AVG WSD = 6.84 *MPH*
AVG WSD 10 *MPH OR GREATER FOR* 194 *HOURS.....PERCENT OF MONTH* = 26.94
AVG TEMP = -0.42 *C*
ENERGY CONSUMED = 14.00 *KWH.....(BASED ON* 605.86 *A-H)*
ENERGY PRODUCED = 6.62 *KWH.....(BASED ON* 262.60 *A-H)*
SYSTEM OPERATIONAL FOR 270 *HOURS.....PERCENT OF MONTH* = 37.50
TURBINE RUNNING DURING 65 *HOURS.....PERCENT OF MONTH* = 9.03
TOTAL HOURS IN MONTH = 720

UNCLASSIFIED

AD-A083 961 DEFENCE RESEARCH ESTABLISHMENT OTTAWA (ONTARIO) F/G 10/2
EVALUATION OF THE VERTICAL AXIS WIND TURBINE AT DREO.(U)
JAN 80 H R BRAUN, D J BRISTOW, S J WAKE
UNCLASSIFIED DREO-R-822 NL

DECEMBER 1978

DAY	AVG WSD (MPH)	10+ MPH (HOURS)	AVG T (C)	AVG V/B (VOLTS)	A-H OUT	E/OUT (KWH)	A-H IN	E/IN (KWH)	OP (HOURS)	RUN (HOURS)
1.00	3.25	0.00	-4.06	23.24	54.96	1.28	0 80	0.02	24.00	1.00
2.00	5.42	2.00	-10.10	22.99	54.34	1.25	0.10	0.00	24.00	1.00
3.00	7.83	11.00	-16.31	22.66	53.61	1.21	0.30	0.01	24.00	1.00
4.00	10.25	13.00	-1.75	22.83	53.89	1.23	39.60	0.90	24.00	8.00
5.00	8.21	9.00	-0.10	22.62	54.48	1.23	45.30	1.02	24.00	10.00
6.00	6.13	0.00	1.55	9999.00	52.93	1.27	1.60	0.04	24.00	3.00
7.00	4.92	3.00	-3.61	22.39	52.69	1.18	12.00	0.27	24.00	4.00
8.00	5.33	2.00	-3.14	22.19	52.52	1.17	10.90	0.24	24.00	3.00
9.00	3.83	1.00	-7.86	21.78	51.57	1.12	0.00	0.00	24.00	0.00
10.00	7.25	9.00	-18.25	21.29	50.37	1.07	0.00	0.00	24.00	0.00
11.00	0.71	0.00	-11.46	20.92	49.48	1.03	0.00	0.00	24.00	0.00
12.00	0.50	0.00	-4.05	20.54	48.64	1.00	0.00	0.00	24.00	0.00
13.00	9999.00	9999.00	0.06	20.05	47.65	0.96	0.00	0.00	24.00	0.00
14.00	9999.00	9999.00	-9.49	19.77	47.06	0.93	0.00	0.00	24.00	0.00
15.00	9999.00	9999.00	-2.60	19.71	46.98	0.93	0.00	0.00	24.00	0.00
16.00	9999.00	9999.00	-0.56	19.17	45.71	0.88	0.00	0.00	24.00	0.00
17.00	9999.00	9999.00	-4.40	18.48	44.07	0.81	0.00	0.00	24.00	0.00
18.00	18.67	12.00	-15.95	18.86	18.38	0.35	0.00	0.00	13.00	0.00
19.00	13.00	21.00	-15.26	23.50	0.00	0.00	0.00	0.00	0.00	0.00
20.00	7.67	9.00	-13.81	24.51	0.00	0.00	0.00	0.00	0.00	0.00
21.00	11.83	16.00	-9.49	25.55	0.00	0.00	0.00	0.00	0.00	0.00
22.00	4.83	0.00	-12.06	26.51	0.00	0.00	0.00	0.00	0.00	0.00
23.00	7.14	1.00	9999.00	27.37	0.00	0.00	0.00	0.00	0.00	0.00
24.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
25.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
26.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
27.00	9999.00	9999.00	9999.00	9999.00	0.00	0.00	0.00	0.00	0.00	0.00
28.00	10.00	9.00	9999.00	26.79	0.00	0.00	0.00	0.00	0.00	0.00
29.00	3.58	0.00	-17.22	26.78	0.00	0.00	0.00	0.00	0.00	0.00
30.00	6.08	1.00	-10.60	26.66	0.00	0.00	0.00	0.00	0.00	0.00
31.00	9999.00	9999.00	9999.00	26.59	0.00	0.00	0.00	0.00	0.00	0.00

***** 9999.00 *INDICATES INCOMPLETE OR NO DATA AVAILABLE*****

UNCLASSIFIED

DECEMBER 1978 (Cont'd)

AVG WSD = 6.97 MPH.....BASED ON 21 DAYS
AVG WSD 10 MPH OR GREATER FOR = 119 HOURS (SEE MONTHLY LOG).....PERCENT OF MONTH = 15.99
AVG TEMP = INCOMPLETE DATA (SEE MONTHLY LOG)
ENERGY CONSUMED = 18.90 KWH.....(BASED ON 879.33 A-H)
ENERGY PRODUCED = 2.50 KWH.....(BASED ON 110.60 A-H)
SYSTEM OPERATIONAL FOR 421 HOURS.....PERCENT OF MONTH = 56.59
TURBINE RUNNING DURING 31 HOURS.....PERCENT OF MONTH = 4.17
TOTAL HOURS IN MONTH = 744

UNCLASSIFIED

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1 ORIGINATING ACTIVITY
Defence Research Establishment Ottawa
Department of National Defence
Ottawa, Ontario K1A 0Z4

2a. DOCUMENT SECURITY CLASSIFICATION
UNCLASSIFIED

2b GROUP
N/A

3. DOCUMENT TITLE

EVALUATION OF THE VERTICAL AXIS WIND TURBINE AT DREO

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
REPORT

5. AUTHOR(S) (Last name, first name, middle initial)

BRAUN, Howard, R., BRISTOW, David J. and WAKE, Sylvia J.

6. DOCUMENT DATE	7a. TOTAL NO OF PAGES	7b NO OF REFS
JANUARY 1980	97	6

8a. PROJECT OR GRANT NO	9a ORIGINATOR'S DOCUMENT NUMBER(S)
	DREO REPORT NO. 822
8b. CONTRACT NO	9b. OTHER DOCUMENT NO (S) (Any other numbers that may be assigned this document)

10. DISTRIBUTION STATEMENT

UNLIMITED DISTRIBUTION

11. SUPPLEMENTARY NOTES	12. SPONSORING ACTIVITY

13. ABSTRACT

A Vertical Axis Wind Turbine-Battery Storage System was installed at the Defence Research Establishment Ottawa in December 1975 and was operated for three years. The system was instrumented to control and monitor its operation and performance.

This report deals with an evaluation study of a Vertical Axis Wind Turbine-Battery Storage System for a low-power unattended power source. The System's wind turbine, energy-generating and battery-storage system, mechanical drive system, installation, control-circuitry and data-acquisition system are described. Also, a performance-history outlining the problem areas encountered and a data-summary of two years of performance-data acquired during this study are presented.

The objective of this study was to assess the System's ability to provide sixty watts of continuous power. The frequency of mechanical failures, especially in the turbine electrical drive system, made this particular system unsuitable as an unattended power source. It was also concluded that the average annual windspeed in the test location was of insufficient magnitude to provide the specified power output.

UNCLASSIFIED

DSIS

77-065

KEY WORDS

WIND

TURBINE

VERTICAL AXIS

EVALUATION

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the organization issuing the document.

2a. DOCUMENT SECURITY CLASSIFICATION: Enter the overall security classification of the document including special warning terms whenever applicable.

2b. GROUP: Enter security reclassification group number. The three groups are defined in Appendix 'M' of the DRB Security Regulations.

3. DOCUMENT TITLE: Enter the complete document title in all capital letters. Titles in all cases should be unclassified. If a sufficiently descriptive title cannot be selected without classification, show title classification with the usual one-capital-letter abbreviation in parentheses immediately following the title.

4. DESCRIPTIVE NOTES: Enter the category of document, e.g. technical report, technical note or technical letter. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the document. Enter last name, first name, middle initial. If military, show rank. The name of the principal author is an absolute minimum requirement.

6. DOCUMENT DATE: Enter the date (month, year) of Establishment approval for publication of the document.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the document.

8a. PROJECT OR GRANT NUMBER: If appropriate, enter the applicable research and development project or grant number under which the document was written.

8b. CONTRACT NUMBER: If appropriate, enter the applicable number under which the document was written.

9a. ORIGINATOR'S DOCUMENT NUMBER(S): Enter the official document number by which the document will be identified and controlled by the originating activity. This number must be unique to this document.

9b. OTHER DOCUMENT NUMBER(S): If the document has been assigned any other document numbers (either by the originator or by the sponsor), also enter this number(s).

10. DISTRIBUTION STATEMENT: Enter any limitations on further dissemination of the document, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this document from their defence documentation center."

(2) "Announcement and dissemination of this document is not authorized without prior approval from originating activity."

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document, even though it may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall end with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (TS), (S), (C), (R), or (U).

The length of the abstract should be limited to 20 single-spaced standard typewritten lines; 7½ inches long.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a document and could be helpful in cataloging the document. Key words should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context.